Vol. VI, Part I Quarterly JANUARY, 1911

The Agricultural Journal of India

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AGRICULTURAL RESEARCH INSTITUTE
PUSA

PUBLISHED FOR
THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA
BY
THACKER, SPINK & CO., CALCUTTA
W. THACKER & CO., 2, CREED LANE, LOND

Price, Rs. 2

EDITED BY

The Inspector-General of Agriculture in India

ASSISTED BY

An Advisory Committee of the Staff of the
Agricultural Research Institute,
Pusa, Bengal, India.

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CALCUTTA :
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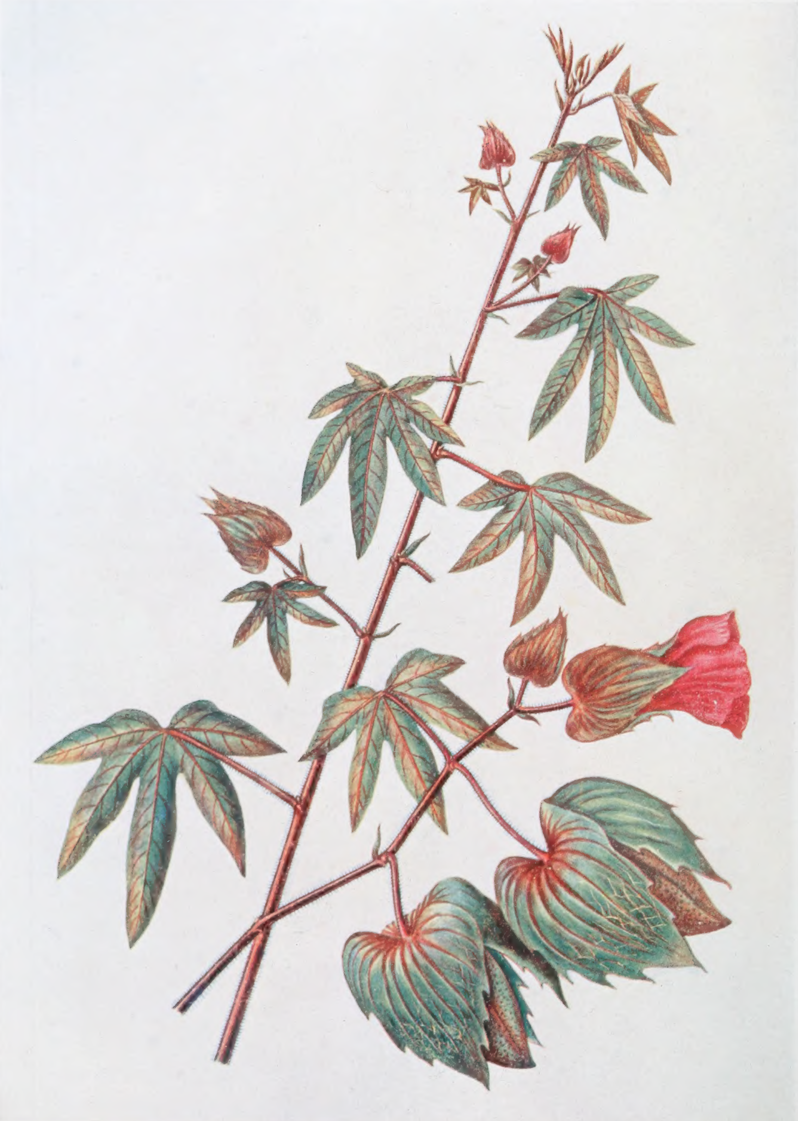


VEGETATIVE AND FERTILE BRANCHES OF COTTON.

Engraved and Printed
by The Calcutta Phototype

THE PROBLEM OF THE IMPROVEMENT OF COTTON IN THE UNITED PROVINCES OF AGRA AND OUDH.

By H. MARTIN LEAKE, M.A., F.L.S.,
Economic Botanist,

AND

A. E. PARR, B.SC., PH.D.,
Deputy Director, United Provinces.

THIS note was originally written at the request of the management of the Agricultural Court, United Provinces Exhibition, and in it are outlined the lines of work now in process of development by the United Provinces Department of Agriculture for the improvement of the cottons grown in the Provinces.

This work in its entirety consists of two distinct sections, the production of an improved type, or types, suited to the agricultural conditions of the Provinces and their introduction into general cultivation. Though at the present time the limits of the preliminary experimental work have barely been reached, it seemed desirable for the purpose then in view to outline the entire problem. A few pure races—the outcome of the earliest crosses—are at a sufficiently advanced and promising stage to be subjected to field trial. These are, however, only derived from preliminary crosses, made at a time when a very elementary knowledge of the different types of cotton cultivated was available. With a more complete knowledge of these types, further crosses have been made from which still further improvement is confidently anticipated, but of which it is still too early to speak with certainty.

Though cotton is grown throughout the United Provinces, the tract where it is most largely cultivated and where the crop forms over 30 per cent. of the total *Kharif* area is situated in the western districts. Throughout this area, and throughout the greater portion of the rest of the Provinces, a single species of cotton is cultivated which has been termed *Gossypium neglectum* Tod. by Gammie, but is classified as two varieties *var. neglecta and var. rosea* of the Linnean species *G. arboreum* by Watt. Within this single species, however, a large number of forms exist which are distinguished by certain minor characters. Thus the flowers may be yellow or white ; the leaves slightly, or deeply, dissected and the glands of the leaf may be present or absent. The lint of all forms is short and coarse though there are degrees in the length of fibre and in the proportion of lint to seed in the *kapas*. Further, though the lint of the widely cultivated forms is invariably white, a certain number of plants can be found here and there in which the lint colour is of a rich red brown, or *khaki* colour.

Such is the condition of the main cotton crop of the Provinces at the present day. Its main characteristics are the shortness and coarseness of the lint and the great confusion of types which are, with few exceptions, grown in one field. These types are the truly indigenous cottons of India. In addition to this the numerous importations of foreign seed, chiefly from America, but also from Egypt, which have from time to time taken place, have left their mark on the Provinces and in most districts plants of this type can be found. The latest and most determined of these importations is that made by the Department of Agriculture, United Provinces, into the cotton districts round Aligarh. The American type can now here and there be found growing as a field crop but, for reasons which are probably partly economic and partly agricultural, its cultivation has not spread and it is unlikely that it will replace to any extent the indigenous forms.

Lastly there is one more group of cottons which is found as a crop within the limits of these Provinces. This is a group characterised by the *Radhiya* of the eastern districts and is the *G. intermedium* of Gammie. Its cultivation is limited to the eastern districts such as Gorakhpur and Allahabad but extends into Bengal. It is found growing alone but more commonly as an element of a mixed crop. The crop occupies the ground for a lengthy period and begins to yield towards the end of the cold weather. It is, therefore, quite unsuited for cultivation in any area where the cold is sufficient to check growth, and largely for this reason its cultivation is centred in Bengal and extends only to the eastern districts of the United Provinces where the more temperate climate permits of its growth.

In addition to the above, which form the field cottons of these Provinces, there are a few forms which are found as isolated plants scattered here and there throughout and only occasionally found as a field crop. Among these are forms with a *khaki* lint, both of the American and Indian type, and especially the *Narma*, or red flowered cotton—the *G. arboreum* of most writers. This form is of considerable importance as possessing the longest staple of any cotton indigenous to the Provinces. It is found chiefly in the vicinity of temples where a few plants may be found from the fibre of which the Brahmanical thread is spun. It is a perennial and, like the *Radhiya* already described, very late flowering. Its yield in the first year is consequently very light and its cultivation quite unremunerative as a field crop.

In problems of the present nature success is frequently dependent on the degree to which the aim receives clear definition in the mind. Only by so doing can the best lines on which the work may be developed, be determined with any certainty. It is, therefore, of the utmost importance in the present case to obtain such a clear definition and the problem must now be approached from this point of view.

In its agricultural aspect the aim of all improvements should be the increase in the return of a unit area of land. This increase may be procured by a reduction of working expenses in production or by an enhancement in value of the produce, which enhancement may be obtained either by increasing the yield of a given produce or by improving the quality and hence value of the article produced, in which case even a diminution in gross yield may be permissible. In the case of cotton the problem is complicated by the fact that the agricultural is not the sole aspect. There exists within these Provinces a considerable industry using cotton as its raw material whose interests cannot be ignored. Nor can it be assumed on *à priori* grounds that the agricultural and industrial interests are coincident. In the present instance that the two interests are, to a large extent concurrent is, we think, fairly clear. It may be that temporary circumstances for the time have made quantity of major, and quality of minor, importance; but it is quality which will pay in the long run, and this, therefore, is the point to which most attention has to be paid. There are, it is needless to say, degrees in quality, and it is not suggested that it would be economically sound to produce the finest grades of cotton. What it is desired to aim at, rather, is a cotton of medium length capable of spinning between 30's and 40's and with a silky texture—this latter character in all probability depending on the diameter of the individual fibres.

In the scheme for improvement here outlined, we are not concerned with any such methods as are dependent on the cheapening of the cost of production. In the present case there is little scope for such improvement before the produce reaches the ginning factory, nor are we concerned, except in the broadest manner, with methods for increasing indirectly the fertility of the land on which the crop is grown, such as cultivation and manuring; under present circumstances these too afford small opening for any large improvement. What we are concerned with is that improvement which is dependent on the physiological and morphological characters of the cotton plant itself—characters which are not to any large extent affected by the environment.

It follows from this that any practical improvement can only be obtained as the result of a close study of the characteristics of the cotton plant which study must precede any work aiming at a practical end. The work, therefore, falls roughly into two divisions, the purely scientific preceding and the practical following.

PLATE I.

A. J. I. A PLANT PROTECTED AGAINST CROSS FERTILIZATION.

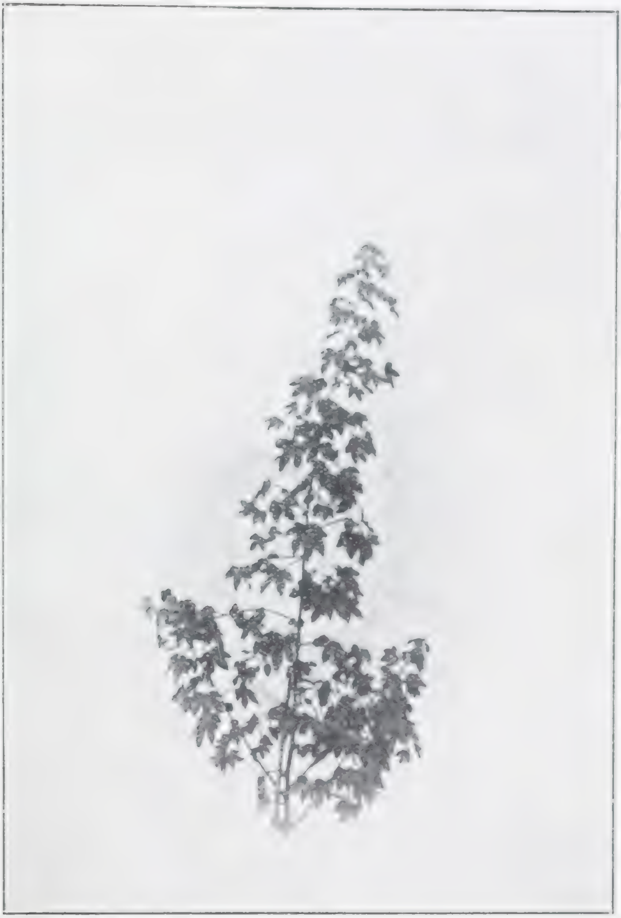
We have already shown that the cotton crop as it is grown throughout the Provinces consists of a large mixture of types. The first step of importance, therefore, is to find out the units of the crop, by which is meant the number of forms which can be isolated and grown in pure culture. Having obtained these, the second step is to find out the unit characters of the plant, that is, the characters of lowest magnitude which can be traced as units from generation to generation. This may be explained by a concrete example. The flower of the cotton plants of these Provinces are of three colours, the red flowered *Narma* and the yellow and white flowered *Desi*. There also occurs in the Punjab a pink flowered cotton, though we have no record of its occurrence in these Provinces. Now these four forms of flower colour are not four separate characters, but arise from two only, each of which may be present or absent. On the combination of these two characters depends the resultant colour of the flower. Thus the two colour characters are yellow and red. When both colours are present the flower has the full red colour ; when red is present and yellow is absent the flower is pink, while if yellow is present and the red absent the flower is yellow. Lastly, if both are absent, the flower will be white. That this represents the true facts is shown by the ease with which it is possible, starting with only pure red and pure white flowered types, to breed out pure pinks and yellows, and in like manner it is possible to obtain pure white and pure red flowered plants starting with the yellow and pink forms only. From this single simple example some idea may be gained of what is meant by a unit character. The method by which such unit characters are determined is also indicated to some extent in the above, and consists usually in crossing pure types differing in one or more characters and observing the behaviour of these characters in the next and subsequent generation.

It is possible that a certain amount of practical result may be obtained directly from the preliminary isolation of pure types. In the extensive mixture of forms found throughout the cotton growing area it has been found that comparatively few pure types exist. The remainder of the crop is composed of intermediate forms, the result of natural cross-fertilization. Such intermediates will never breed true but give an indefinite number of forms together with a few plants agreeing with one or other of the pure types. Now, in such a mixture, there can be little doubt that some of the forms are inferior to others and it is possible that, by isolating the pure forms, a superior form may be found and its cultivation introduced. There is no prospect of improvement of quality by such means, but an improvement in quantity is to be looked for. Thus some of the *Desi* types of cotton are notably heavy yielders with a high percentage of lint and in some districts even now are grown in a nearly pure state. The purification, and subsequent distribution, of these gives one line of improvement, but it must be emphasised that that improvement is practically limited to quantity. Work on these lines is now in progress at Aligarh.

That there is opening for improvement by direct plant selection within such a pure culture admits of no hope. The most selection can here do is to check any diminution in yield, chiefly by rigorously maintaining the purity of the seed. Owing to the extent to which cross-fertilization takes place in nature it is a matter of some difficulty even to keep the more distinct types in a state of purity when they are grown on a small scale and, even when working on a big scale, it is essential to undertake precautions such as roguing to maintain the purity of the crop. It will be readily understood, therefore, that it becomes a matter of practical impossibility to separate those small and scarcely perceptible characters on the selection of which improvement within a pure type depends.

Thus far we have considered an improvement in the gross outturn only—the quality remaining practically the same. This, however, is not the main direction in which improvement is to be expected. This, as we have stated above, is to be found in the improvement of the quality, length and fineness of the lint. For this purpose we must turn elsewhere, to the results, that is, which have been obtained in our search for the unit characters.

PLATE II.



A. J. I. AN EARLY FLOWERING PLANT.

It is at this stage that the clear picture which we have formed of what it is desired to procure will be of the utmost importance. Let us for a minute examine this picture in greater detail than we have hitherto. It is a plant, which, when sown at the beginning of the rains, will be ripening fruit by the beginning of October, that is, it must be in flower by the end of August giving a vegetative period of about 70—80 days. In other words it must be early flowering; it will be vigorous, a good yielder with a large boll and a high percentage of lint; the lint must be fine and silky and of a length rendering it suitable for spinning between 30's and 40's, which may be placed roughly as 1 inch.

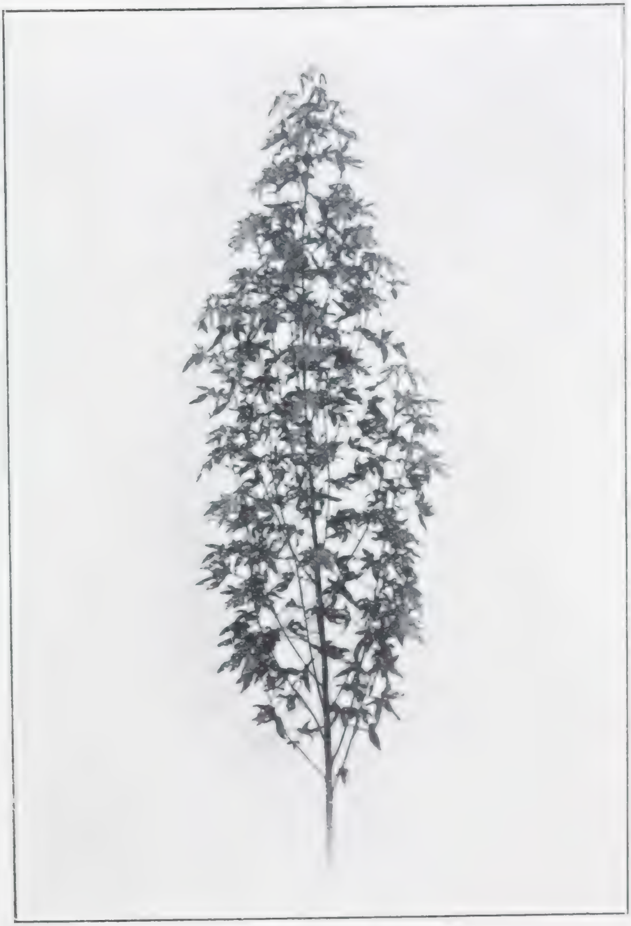
Of other points of secondary, but, nevertheless, sufficient, importance to render them worth consideration may be mentioned the obvious advantage of a red flowered form. We have already drawn attention to the dangers of natural cross-fertilization. There is also the danger of seed admixture. These are very real dangers which must be faced or a new form may easily be swamped at the start by either of them and thus lost. The advantage of some such character as a red flower, by which a casual inspection will at once disclose any admixture or impure plants would form a check of inestimable value in the early stages of introduction.

The material from which it is proposed to obtain the plant just described has already been briefly detailed. Considered from this point of view, it consists of the series of forms all with the early flowering characters and some possessing the heavy yield and good percentage lint, but lacking both the length and fineness.

There occurs in isolated places among these forms a type, allied to the Hinganghat cottons of Central India, possessing the silky fibre but lacking the length of the latter. There are again the cottons of the eastern districts; these, however, have a late flowering period, nor is the lint of much value while the percentage is very low. Lastly, there is the red flowered *Narma*, very late flowering but possessing a good staple, moderately silky and having red flower and foliage. If we go outside these Provinces there are also the true Hinganghat plant, an early flower with long and silky lint but incapable of producing a good yield or sufficiently robust; the Broach cotton with a good staple but very late flowering, and the Assam cotton whose only good character is the size of boll and percentage lint, the lint being, however, excessively short.

Before considering how this material is to be utilised we must examine the conditions under which this work has to be carried out. Here the difficulties are considerable. Thus it has been found impossible to use the Broach cotton as a parent, the crosses from it appearing almost sterile. Again, cross-fertilization in nature has been found to occur on a scale which renders it imperative to use only the seed from protected flowers, and the labour involved in such protection is considerable. Again, continued self-fertilization, such as occurs with protected flowers, has been found to lead to a considerable degree of sterility so that the breeder has to beware of falling into either the Scylla of mixed offspring or the Charybdis of no offspring at all. Lastly, but not of the least importance, is the impossibility of ascertaining, except in a very limited number of cases, the quality of the staple until it is too late in the season to procure seed from protected flowers. By the time the boll ripens and exposes the cotton the plant has practically ceased flowering and it is impossible to obtain self-fertilized seed. At certain stages, then, it becomes a matter of speculation as to which plants shall be taken, for, so far, no correlation has been found by which the quality of staple can be determined before it can be actually handled. When it is noted that, to take one case which occurred in practice, it has been found that out of some 400 plants one only possessed the desired combination of characters, the speculative nature of the proceeding and the necessity of dealing with large numbers becomes apparent. In the event of failure to self-fertilize the desired plant it will be necessary to rattoon it and procure seed from it next season, thus losing a whole year, with the alternative of using seed

PLATE III.



A. J. I.

A LATE FLOWERING PLANT.

which may or may not be pure. This difficulty is far the most important that has to be faced in this work.

Such are the conditions and such the materials with which it is proposed to produce the types of plant of which a description has been given above. The length of staple occurs in the Broach, *Bani* and *Nurma* cottons, but, as has already been stated, Broach has been found unsuitable owing to the sterility of the crosses. We are left then with the *Bani* and *Nurma* cotton, the former of these being altogether too weak in habit and light in yield to form a field crop in these Provinces, while the latter flowers too late to give any yield in the first year and has to be grown as a perennial. Moreover in both these forms the boll is small.

Silkiness is characteristic of the *Bani* cotton and is confined practically to that kind.

Hardiness and yield combined with a high lint percentage are essentially the characteristics of the *Desi* cottons of the Provinces and more especially of the white flowered forms. While for size of boll the cotton of Assam stands before all others.

The *Nurma* alone of the Provincial cottons possesses the red flower which, for the reasons given above, is a desirable character in the plant we have outlined.

In the earlier experiments two crosses have been relied on for practical results. These are a cross between *Nurma* and the short stapled but silky form of *Bani* found in these Provinces, the possibilities of which cross were indicated as early as 1870 by Major Trevor Clarke, and one between *Nurma* and white flowered *Desi*. In this former cross we rely on the *Nurma* to obtain length of staple and the red flower, while from the *Bani* we hope to derive the silkiness of fibre and the early habit. The plant is likely to be somewhat deficient in size of boll, and consequently yield, and in percentage of lint since neither parent possesses these characters to any marked extent.

In the latter cross length of staple and percentage of lint may both be expected, combined with the red flower, but the silkiness of the fibre will be lacking.

These two crosses have been actually effected and pure races isolated of which we give below a report by Mr. A. F. Horsman, on small samples of the lint from each; the first is from the former, and the second and third from the latter, cross.

"Sample 131. Very good cotton, will spin 20's to 30's warp, even staple $\frac{3}{4}''$ to $\frac{7}{8}''$ long; silky and colour good and would spin 36's weft.

"It was compared with some fine Cawnpore machine ginned cotton (*Gangapar*) which was fully $\frac{1}{8}''$ to $\frac{3}{16}''$ shorter in staple and will spin up to 16's only.

"In regard to prices, I should value it at Rs. 325 per candy (784 lbs.) as against Rs. 275 for fine Cawnpore machine ginned cotton and I consider it equal to fine Broach.

"Sample 401. This is better than ordinary *Desi* but not so good as No. 131. The staple is not so regular nor as fine but is firm and of fairly strong fibre; would spin 15's to 20's.

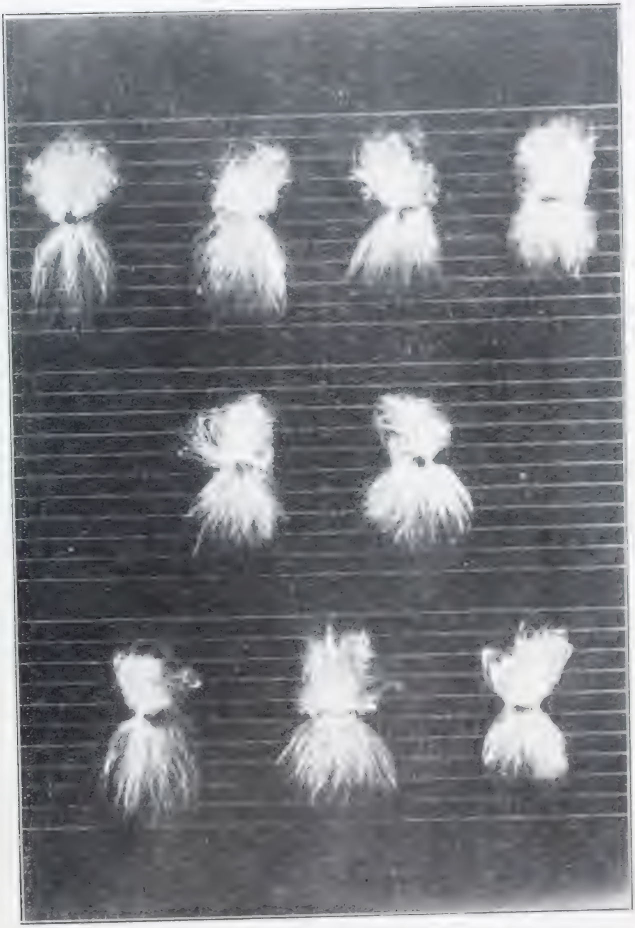
"Sample 651. This is between Nos. 131 and 401, not quite so coarse as No. 401 but very good for *Desi* cotton.

"Sample too small to form a definite opinion."

It remains only to add that this report is given on samples which were taken without any idea of having them valued. The object in taking them was to obtain as much seed as possible so that they contained, in addition to the lint from healthy bolls also that from badly diseased bolls. During the season 1909 the boll worm was exceptionally prominent and the percentage of diseased bolls very large. These reports, therefore, do not, in all probability, err in the direction of over-estimating the value of the samples. This remark applies especially to the sample 401 which, we believe, to be, in reality, of greater value than the report seems to indicate, the irregularity especially noted being due to the presence of a high proportion of lint from diseased bolls.

These experiments are yet in their infancy, and the limits of improvement by no means reached. Numerous other crosses are now in various stages of cultivation and it is hoped that these will add still further improvement. It is, however, too early to refer to these in detail.

PLATE IV



A. J. I. Top Row. Left, Narma Parent. Right, Bengal Parent.
Middle Row. 1st Generation of Cross.
Bottom Row. 2nd Generation of Cross.
Left, Long Staple—Centre, Medium Staple—Right, Short Staple.

The production of a plant with characteristics which render it suitable for cultivation in these Provinces, and which at the same time gives a produce of enhanced commercial value is only one part of the problem of improvement. There remains the all-important question of the means by which such a plant can be introduced into general cultivation. We are here faced with the conservatism innate to all agricultural populations. The initial stages of introduction into general cultivation of any new plant are always a matter of some difficulty, but this difficulty is here enhanced by the ease with which cottons cross-fertilize and the consequent difficulty in keeping any new race pure during the first few years of its introduction. There is also the difficulty of inducing the consumer to pay the full value for an article which is not well known and only available in small quantities or, if he does pay the full price, in insuring that the actual cultivator reaps the benefit. In a case like the present, where deterioration may so readily occur as the result of cross-fertilization, it seems essential to success that full control shall be kept over the crop during the early stages. The essential features of any scheme for introduction therefore are :—Firstly, to withhold introduction of the produce on to the market until it is available in sufficient quantity to attract purchasers and secondly, to retain under direct control what may be termed a centre of purity for the crop, that is, a central area, or seed farm, in which full precautions can be taken to keep the crop in a state of purity.

The controlling factor is the minimum amount of cotton which will attract the buyers, and the area of this seed farm will be determined by the area it will be necessary to sow to provide this minimum, for it follows from the first condition that the cultivation cannot be entrusted to the cultivators until the year it is proposed to place the produce on the market. Placing this minimum at 500 bales (of 400 lbs.) the area to be sown must be some 1,300 acres in the first year, seed for which will be given from an area of about 90 acres. This, then, is the area which must be sown in one season and over which direct control of the crop must be maintained and from which the pure seed will be distributed to selected cultivators who control between them about 1,300 acres of land.

This distribution in the first year is a comparatively simple matter, but the problem becomes of much greater complexity when the still wider distribution of subsequent years is considered.

The important point to bear in mind in this connection is that the purity of seed is likely to be inversely proportional to the number of years the crop is removed from the time when it was grown on the seed farm. We have no direct information as to the amount of impurity introduced in a single year, but there can be little doubt that it will be appreciable. The conclusion which may be drawn from this is that on no account should seed of a given purity be mixed with seed of a lesser purity and this point must be clearly kept in mind in any scheme of introduction. In practice this demands, at least during the first few years of introduction, that some records be kept of the area in which the new crop is grown. This record will show the particular area under any degree of purity and the *kapas* of each area, so demarcated, will then require to be ginned separately. Interpreted into figures this means that the seed from the farm will have to be distributed to selected cultivators controlling some 1,300 acres actually under cotton in a single season. These cultivators will each year receive a fresh supply of seed from the farm and will not sow seed from the crop grown by themselves. This latter crop will be harvested separately and separately ginned, and the seed distributed to a second series of cultivators controlling some 20,000 acres of land under cotton. In the next year these two areas will be harvested and ginned separately, the original areas of 1,300 acres being again supplied with seed from the farm, the 20,000 acres area being supplied with seed from the crop grown on the 1,300 acres, while the seed from the 20,000 acres will be available for still wider distribution. In this manner a series of, as it were, waves will be established, emanating from the seed farm, which should, in a short period, establish the crop on a firm basis.

Such, in outline, is the scheme for introduction of improved types of cotton. That it can be established with the mathematical precision of the geometrical progression here outlined is hardly to be expected, but there is every hope that sufficient approximation can be obtained to attain the desired result.

PEACH GROWING AROUND PESHAWAR.

BY W. ROBERTSON BROWN,

Superintendent of Farms, North-West Frontier Province.

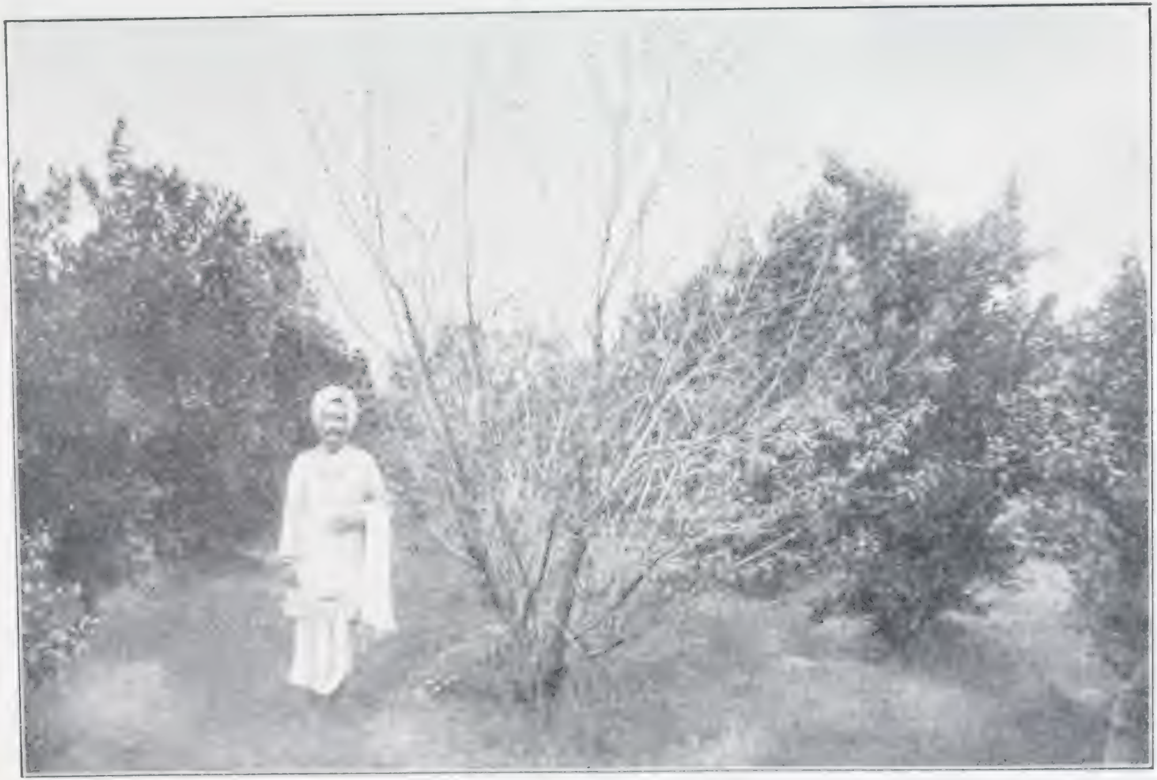
Situation of the Orchards.—Within a radius of 10 miles from Peshawar city, there are probably 100 acres of peach orchards. Peaches are also interplanted to some extent in the pomegranate and plum gardens which lie in the immediate vicinity of the city. The villages of Bahadur and Landi are specially renowned for the size of their orchards and the superior quality of the peaches they produce. The orchards are contiguous and their varying levels show that they ensure efficient drainage.

Average Extent of Orchards.—Peach growers are rarely orchardists pure and simple: they are zemindars, and the planting of an orchard forms part of their agricultural rotation. The orchards range in extent from half an acre to occasionally two acres.

Quality of the Soil.—The red alluvial loam around Bahadur and Landi is remarkably fertile. Wherever the peach orchards are established, the soil is of this kind—red, deep, free and naturally well-drained.

Irrigation.—Practically every orchard is sufficiently irrigated either by the rich muddy water of the Bara, or from the Kabul River canal. The orchards treated from the Bara water are markedly superior in productiveness and quality of the fruit to those irrigated by the Kabul River canal. A few orchards are over-irrigated, as occasionally water is given when the crops are ripening so that the fruits lose greatly in flavour. In the Punjab, the best peaches are produced in orchards which are

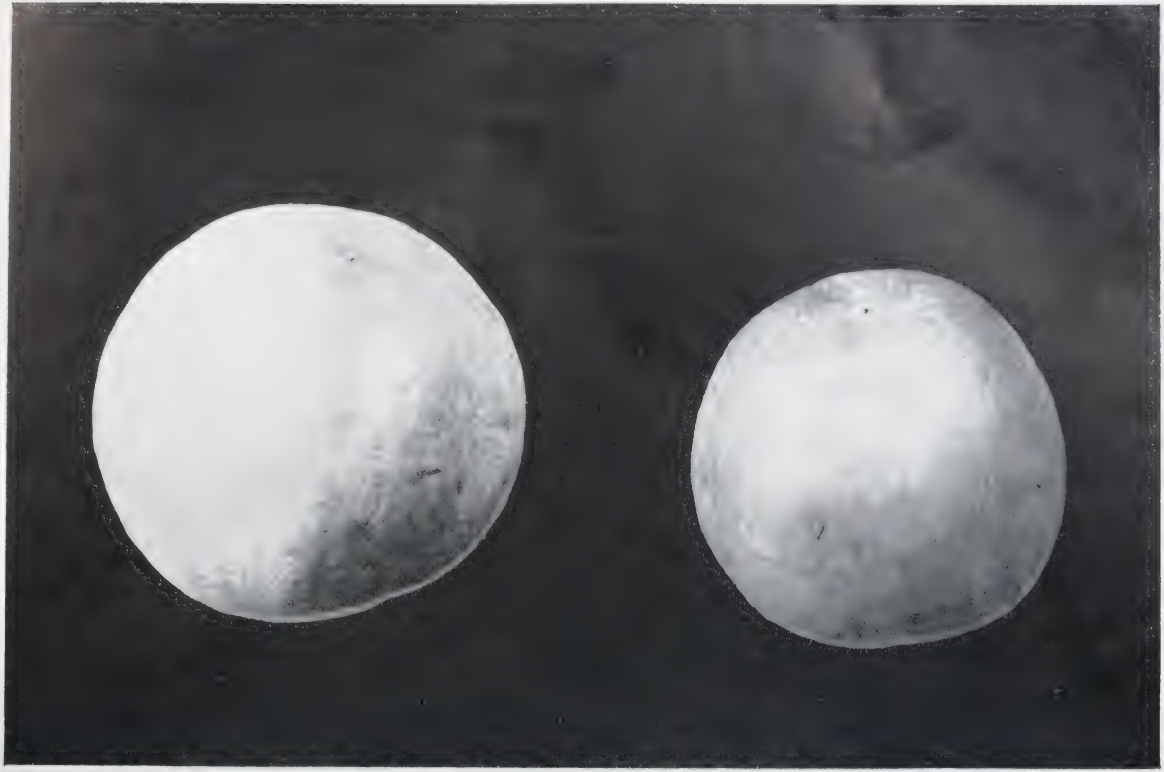
PLATE V.



A. J. L.

Peach killed by Excessive Irrigation.

PLATE VI



A. J. I. PEACH "SAFED." PEACH "LAL."

irrigated by well water. Punjab canal-irrigated orchards invariably do not thrive and are unfruitful. Peshawar canal-irrigated orchards, on the other hand, are naturally drained and therefore suffer less from stagnation. Plate V shows one of many hundreds of Punjab peach trees which were killed in 1908 by the combined ill effects of excessive canal irrigation and an unusually heavy monsoon. These peaches were mostly planted between oranges. It will be seen from the picture that the latter were not injured by the excess of water.

Protection.—Peshawar plum, pear and pomegranate orchards are protected by unsightly and almost formidable mud walls. The soil in these orchards is always moist and the atmosphere damp. It is quite the contrary with the peach orchards; they are entirely in the open and unreservedly exposed to wind, sun and storm.

Trees propagated from Seeds.—There is not an orchard of budded or grafted peach trees in Peshawar. It is probable that there is not one budded peach tree producing fruit. The Peshawar orchardists propagate from seeds only: they are generally of opinion that peaches cannot be budded. Even those who know that budding can be done and who can actually perform budding work, do not consider that budding is worth the trouble. There is not a nursery-man in Peshawar who undertakes to supply budded plants. In January 1910, some hundreds of budded peaches were introduced into Peshawar by the Hon'ble the Chief Commissioner. All these plants were given fair treatment and have grown remarkably well; they are now perfect in health and shape and on the average are one-half larger in size than seedling peach plants which were set out at the same time.

Three Outstanding Varieties.—Though Peshawar peaches vary greatly in size, shape and flavour, the fruit growers and fruit dealers roughly class them chiefly according to colour into three kinds, *viz.*, *Safed*, *Lal* and *Pila*. It is said that these three kinds reproduce themselves fairly true to colour from seedling plants and that other important characters are not constant. Plates VI and VII represent good types of *Safed*, *Lal* and *Pila*. The fruits illustrated are described below :—

Safed.—Is the earliest : it ripened late in July. Size is large, shape almost quite round ; nose very slight ; colour even white ; suture scarcely perceptible. The flesh is white even around the stone and is very soft, juicy and melting. The stone is fairly large and the flavour is good. Its weight is 16 tolas.

Lal.—Is the second early ; it ripened on 3rd or 4th August ; size large ; nose decided ; colour flushed and shaded crimson ; suture slight. The flesh which is veined crimson and deeper around the stone is fairly firm and moderately juicy. The stone is medium in size. The flavour is good. It weighs 15½ tolas.

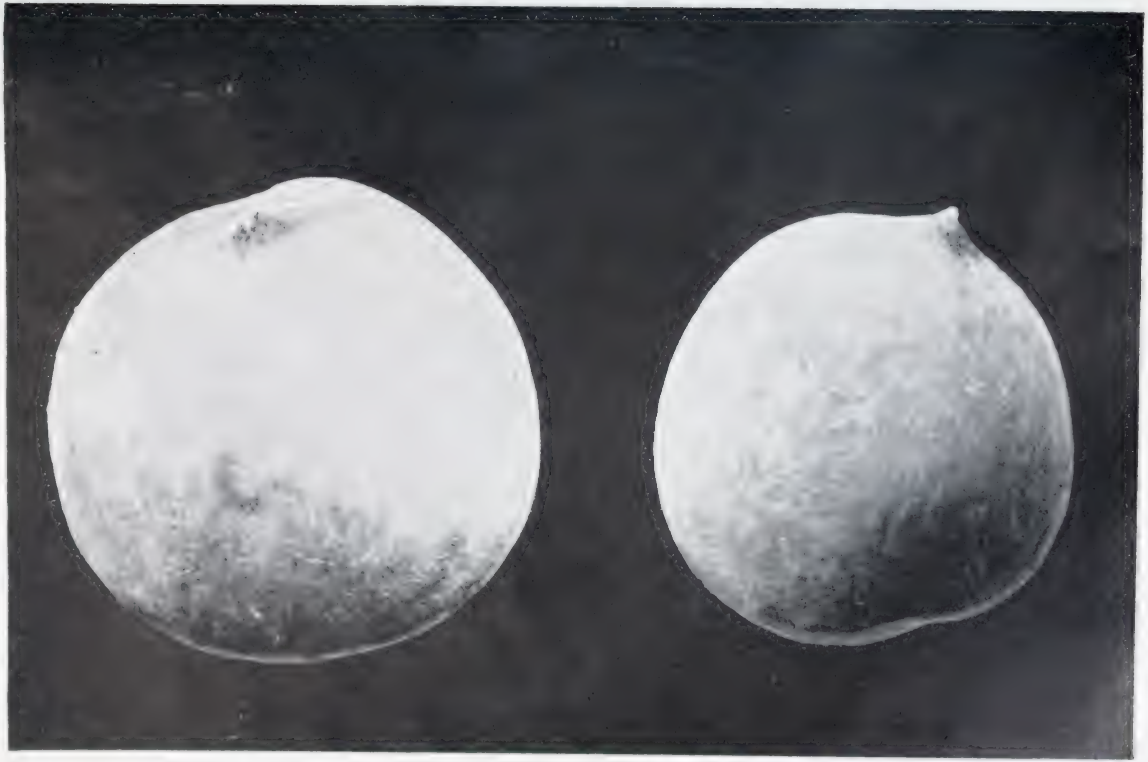
Pila.—Is the latest ; it ripened on 8th August (fruits were picked till 20th August). Size medium ; nose entirely absent ; beautifully round in shape, suture absent. The flesh is golden yellow throughout ; firm and juicy. Flavour sweet and delicious. It weighed 14 tolas.

There are good intermediate varieties of these types. *Lal-Pila* and *Lal-Safed* are most frequently found. In all round merit, the three varieties described are equal to high class English outdoor wall peaches.

Setting out.—Two seedling peaches, 16 months of age, are planted together in blocks or beds 16′ × 16′ or 18′ × 18′ apart, and the pits in the centre of these blocks in which the trees are planted are 1 foot in diameter and 1 foot in depth. The orchardists plant two trees in each block in the hope that at least one of the plants will flourish. But he never removes the second plant if both grow away. The average life of the Peshawar peach orchards is under eight years. The Lahore peach orchards are profitable up to their twelfth year.

Seed Sowing.—A few careful cultivators take seeds from selected fruits only, but here commonly there is no selection. In October a seed bed is prepared, varying in size according to probable requirements and the seeds are sown broadcast and thickly at a depth of about three times the size of the seeds. The young seedlings are not thinned. When planting time

PLATE VII.



A. J. J. Peach "Peca." Peach Nectarine.

PLATE VIII.

Peach Orchard, 2½ years of age, with Vegetable Intercrop.

comes, 16 months later, the seedlings are attenuated plants quite unfit for orchard planting and can be purchased at Re. 1 per hundred.

Catch Crops.—Maize is taken from the young peach orchards as a *kharif* crop for two or sometimes three years, or *jowar* is sown for fodder. Practically any catch crop desired is grown for at least two years. Around Lahore, vegetables, and frequently oats, are taken from young peach orchards. Plate VIII shows 2½ years old orchard with an inter-crop.

Manuring and Cultivation.—For maize or *jowar* a dressing of manure is given. The orchard rows are kept stirred and free of grass and weeds for at least four years. Later, in many orchards, cultivation consists in an annual forking over of the soil directly around the trees.

Thinning of the Fruits.—The trees are severely over-cropped. Thinning of the fruits is never carried out. When suggested, the idea is scouted as ridiculous. On English peach walls, one fruit per square foot of covered wall is the maximum crop permitted if good fruits are desired.

Ripening.—*Safed*, *Lal* and *Pila* of all shapes and sizes are planted promiscuously throughout the orchard, but ripening takes place in the order named. If budded plants of these three types were planted in separate rows or blocks, economy would be gained and one watchman could do the work where three or four are now employed : picking would also be made easier. The Peshawar fruit agents would give greatly enhanced prices for blocks of single types. Irrigation should be sparingly given.

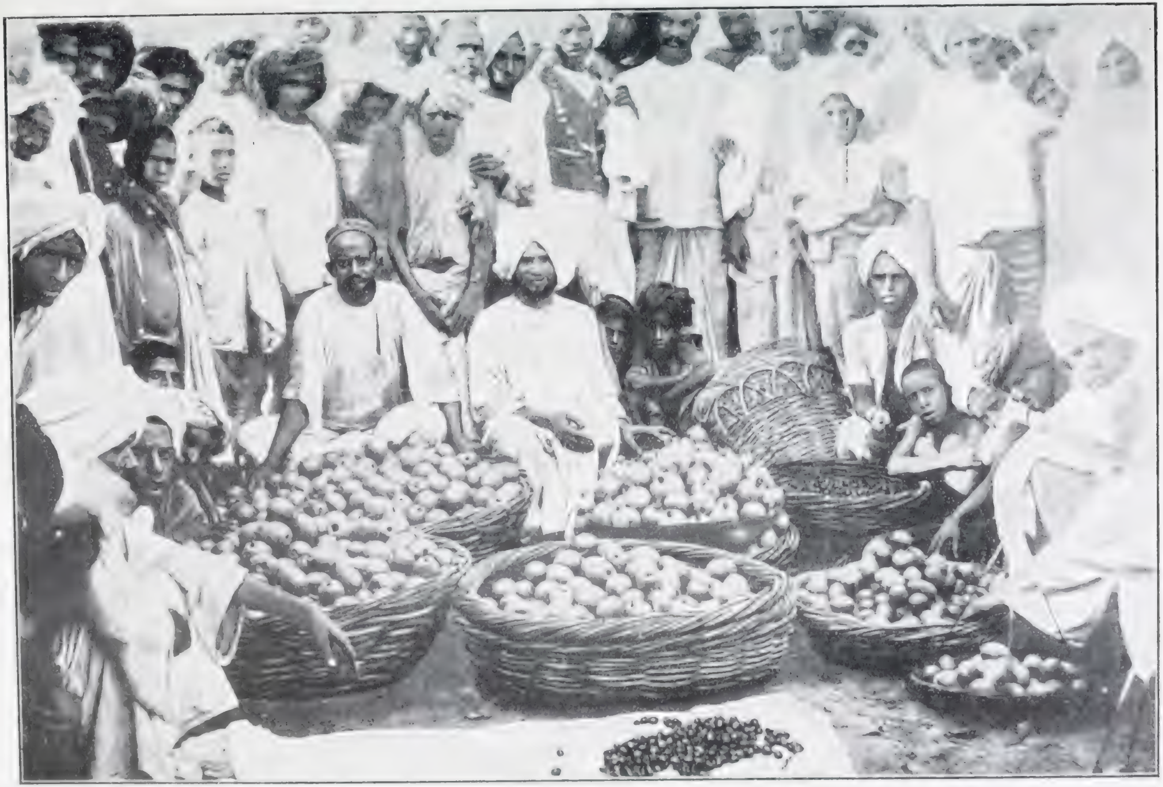
Picking.—The bulk of the peach crop is picked without climbing the trees, for step ladders are unknown in Peshawar orchards and the flexible branches of the trees are gently pulled down towards the pickers. For fruits which cannot be reached from the ground, they nimbly climb the trees and as this operation is done barefoot, little harm results. Nevertheless step ladders would be useful. The fruits are picked when they show colour, but are very far from being ripe. It is chiefly on this account that good conditioned peaches are never seen in the markets.

Marketing.—The peach crops are sold in one of four ways, viz., (i) if the owner of an orchard is poor and he urgently requires money, he sells the estimated crop in January or February to a fruit agent. The price received is in this case very poor: frequently not better than Rs. 100 to Rs. 120 per acre; (ii) the crop is sold when the fruits are approaching the period of ripeness. Rs. 200 to Rs. 300 per acre is the average price received at this time; (iii) fruit agents purchase special varieties from selected trees for despatch to distant stations. Rs. 3 to Rs. 5 per maund are received by the growers for the selected fruits; (iv) the fruit growers pick and market their own fruits in Peshawar. One maund of peaches per tree is considered a very good crop. About 13,500 ten-seer baskets of peaches are despatched from Peshawar from 15th July to 15th September. Ordinary fruits are sent to Peshawar for disposal in large open flat baskets similar to those shown in Plate IX. Fruits to be sent to distant stations by rail are packed in small baskets which carry 10 seers and cost from annas three to annas four. The baskets are conveyed to the city and to the railway station on a cart drawn by two labourers.

Packing.—Grading is practised in a loose fashion. The best peaches are reserved for the 10-seer baskets; the seconds for topping the big flat baskets and the "chipped" fruits are heaped in separate baskets or sold on the spot to villagers, or to the hawkers who have stances during the fruit season at almost every half mile within ten miles of Peshawar. The chipped fruits are very inferior.

The foliage of the orchard trees is slipped from the young shoots of the current season for packing. Each picker, as he requires packing, runs his hands smartly down the shoots and leaves quite 80 per cent. of these as bare. The array of spindly leafless shoots presented in August gives the impression that the peach orchards have suffered heavily from a plague of voracious defoliating caterpillars. Peach foliage is undoubtedly suitable for local packing, but it is short-sighted policy to maim the fruiting trees. The lives of orchards are shortened by one-third by this

PLATE IX.



A CORNER IN LAHORE FRUIT "MANDI."

PLATE X.

A. J. I.

YOUNG PEACH AFFECTED BY "GUMMOSIS."

practice : diseases are prevalent in consequence and the weakened shoots cannot uphold their fruits. Every orchardist could easily grow a seed bed of peaches for the supply of foliage.

Fruit Agents.—The men known as "Fruit Agents" are Peshawar fruit sellers. They have business connections with fruit dealers in Calcutta, Bombay, Lahore, Delhi and other large cities and towns. They send skilled men to pick the fruits and see the baskets on rail. Bills are submitted for all charges including the agent's commission charge for 0-4-0 per basket despatched. Prepayment is insisted on from unknown purchasers. Occasionally when peaches are plentiful and cheap, the Peshawar agents purchase and forward fruits to their distant agent friends to be sold on commission. The money realised, less the usual commission charge of annas four per basket, is remitted to the Peshawar agents. There appears to be the most perfect good faith amongst the fruit agents throughout India in their business transactions.

Railway Troubles.—The fruit agents complain bitterly of the time they are forced to lose at the railway station when booking and forwarding. They and their clients frequently suffer loss and disappointment by theft of the fruits in railway transit.

Diseases and Insect Pests.—Peach insect pests and diseases have not yet been studied in the North-West Frontier Province. "Gummosis" is the most common disease. (Plate X.) The injury done in stripping leaves for packing is undoubtedly the chief cause of the unfortunate prevalence of this disease. The severe annual attacks of green fly are also due to the same deplorable practice. The weak defoliated shoots fall easy prey to sucking insects. Peshawar peach orchards would be remarkably free from disease and insect pests if they were properly treated.

THE BAMBOO WATTLE SILO.

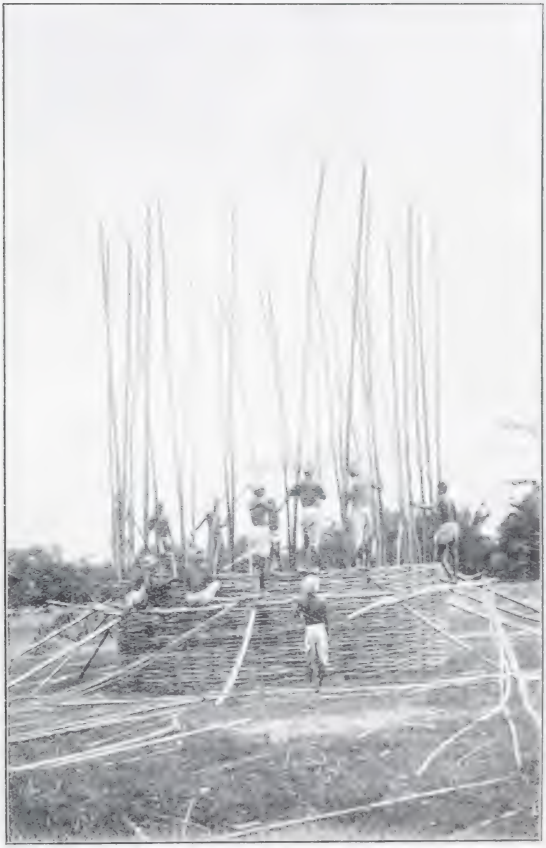
(An Attempt to Construct a Cheap Indigenous Silo.)

By BERNARD COVENTRY,

Offg. Inspector-General of Agriculture in India.

History of Siloing.—The practice of preserving cattle food in a green and succulent condition is of some antiquity, but it is only within the past 25 years that siloing, as now commonly known, has been in vogue. The earlier silos used by people in Europe were simply pits or trenches dug in the ground. Later, these were made of stone, brick, or concrete, and filled with green material, cut or uncut, to which pressure was applied, often not less than 100 lbs. to the square foot. Siloing in stacks was also practised for a time. The material, which in this case was uncut, would be gathered together in the shape of a stack: ropes or chains would be thrown over it to which heavy weights were attached and the necessary compaction thus secured. Both these methods of pit and stack siloing were found to a great extent unsatisfactory in that either the cost of construction was too heavy, or the loss by decomposition was too great, or from both these causes: the quality of the silage, too, was not all that could be desired. It was not until 1876 and following years when dairying became common in America and green food a necessity all the year round, that the attention of the more intelligent farmers was applied to the production of a more suitable method of siloing. The great extent to which Indian-corn or maize is grown in that country undoubtedly favoured the experiments, for it is now generally conceded that maize is the best silo plant in existence, though as I shall show later, sorghum runs it very close and, in my belief, in point of yield per acre entirely beats it.

PLATE XI.



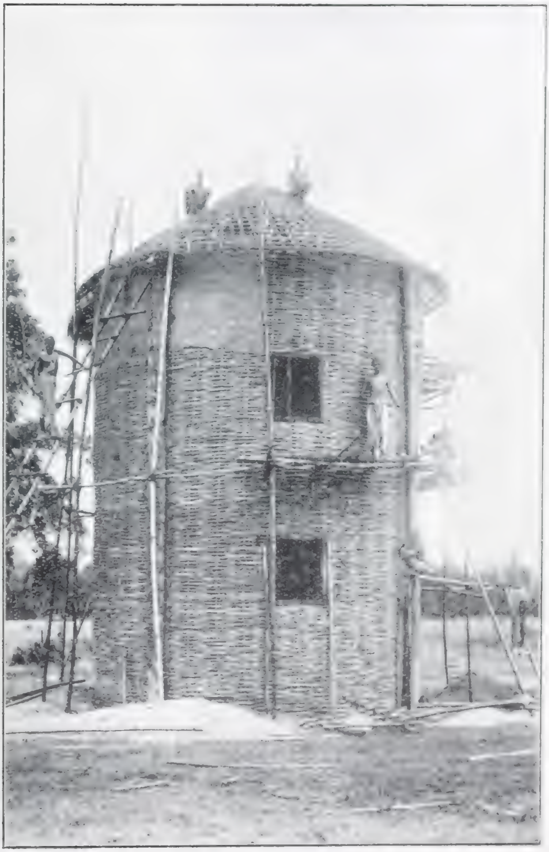
A. J. I. SILO UNDER CONSTRUCTION.

The Modern Silo.—The chief features of the modern silo are that it is narrow and deep instead of broad and shallow, so that pressure is secured from the material itself instead of weighting with stones and other heavy material. It is partially or entirely (mostly the latter) above ground. It is generally round rather than rectangular because in that shape it has relatively greater capacity, can usually be built more cheaply, and its form greatly facilitates the even settling of the silage. It is moreover constructed in such a way as to prevent the ingress of air and moisture at the sides and bottom. The principle on which it acts is as follows. As soon as it is filled with green material cut or uncut (preferably the former as it will settle more quickly and evenly), fermentation sets in and gases (chiefly carbonic acid) are formed which drive out the air until a point is reached when fermentation or combustion ceases for want of air. The great depth of the silo is instrumental in bringing about this point of equilibrium, for the pressure of the material causes such compaction that the air is unable to penetrate. The sides of the silo should likewise be so constructed that air is unable to enter. If either of these features are defective and ingress of air is allowed, the equilibrium will be destroyed and combustion will again set in. It will thus be seen that good compaction and exclusion of air are essential conditions in the successful making of silage. Temperature, too, has a considerable bearing on the quality, for the higher and quicker the temperature rises after the filling of the silo the sooner will the action of the fermenting organisms be arrested and the sweeter will be the silage. An excess of moisture on the other hand in the plant will often keep the temperature low or will rise but slowly, in which case the fermentation will not be checked soon enough and sour silage will result. The deeper a silo the better will be the quality of the silage, and it has been found in America that a depth of 40 feet has usually produced the best results. Such a height, however, adds greatly to cost of construction and of filling. The quality obtained at much lower depths, such as 25 and 30 feet, has been found satisfactory and it is not necessary to go beyond these limits in order to obtain good results, but anything below 20 feet is not recommended.

Experiments in India.—The success which has attended the use of the round silo in America led the writer of this article to experiment with them in India. In 1900, one was constructed of brick at Dalsing Serai, Tirhoot, measuring 20 feet in height and 16 feet in diameter. Owing to its success and the great economy with which green fodder could be preserved, another of the same dimensions was erected by Mr. Hay-Webb at the Mooktapur Indigo Concern in Behar with the same satisfactory results. When the Pusa Farm was built, silos were, in consequence of the success of those at Dalsing Serai and Mooktapur, also put up at Pusa, but owing to defects due to faulty construction the Pusa silos have not made the best quality silage.

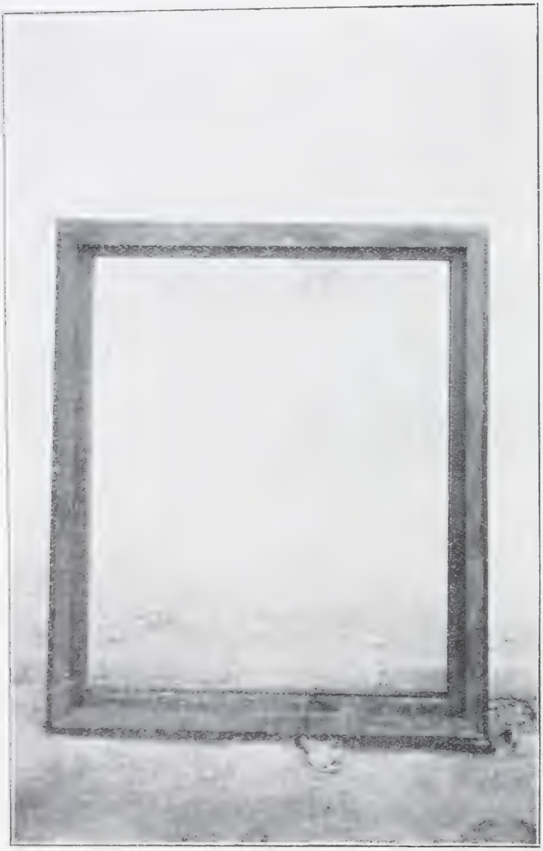
The Wattle Silo.—As the demand for silage was increasing with the growth of the Pusa milch herd, it occurred to the writer to construct a silo having the proper shape and dimensions but constructed of such materials that its cost could easily come within the means of zemindars and the more wealthy cultivators, but which might also be a cheaper means of storing fodder against years of scarcity for the Agricultural and Military Departments. The material selected was, therefore, of the cheapest. It consisted of bamboo wattle covered over with a plastering of mud and a light roof of thatch. The size is 24 feet high by 18 feet diameter. At intervals of 6 feet, windows 4′ × 2′ are let into the wattle, the top window being cut into the roof and provided with a weather-roof. (Plate XI.) The construction was extremely simple. Bamboos were planted in the ground 3 or 4 feet apart in a circle 9 feet diameter, and split bamboos were wattled between these bamboos. (Plate XII.) When the desired height was reached (in this case 24 feet), 4 posts made by splitting two palmyra palm trees each into half, were planted 6 feet in the ground and lashed with rope or wire against the wattling at equal distances apart. This stiffened the whole structure and prevented bulging or falling over. The windows were next put in. This is not an easy matter when

PLATE XII



A. J. I. Silo-Wattle complete and Windows put in.

PLATE XIII



A. J. I. Window of Silo (*from inside*) showing Groove.

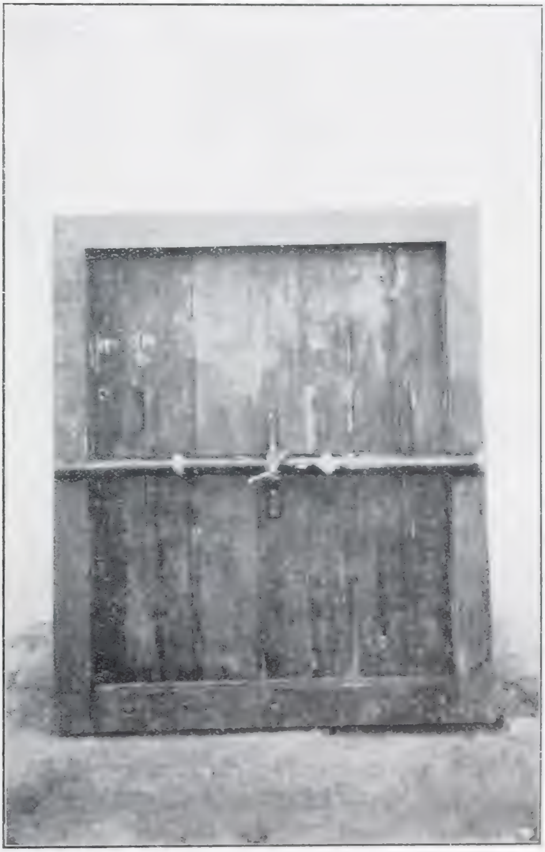
dealing with wattle. Before the space for the window was cut, two frames of the size of each window, of 3″ × 1″ board were first made ready. One of these frames was placed inside the silo, the other outside in such a way that they exactly coincided with each other. When in this position, they were firmly bolted together with 4 or 6 screw bolts, the wattle being between the two frames. The next operation was simple; with a hand saw the bamboo wattle that came within the frames was cut away and a firm well set window was the result. (Plate XIII.) In this way, the bottom and middle windows were inserted 6 feet apart. This distance, being about equal to the height of a man, is suitable when unloading the silo. In order to close the window a flap made of one inch board is provided. This fits into a groove made in the inner frame of the window, and is kept in position by a bamboo outside tied to an iron staple in the centre of the flap and twisted till it catches firmly against the window frame. (Plate XIV.) When the silo is filled, the flap will keep its place from the pressure inside. In order to prevent air getting in at the sides of the flap, the groove should be well puttied before the flap is put in. The top opening is made by cutting into the roof and fixing a weather-roof over it. It is necessary to have an opening above the height of the silo in order that it may become filled to the brim and that the full capacity of the silo may be utilised. The roof itself is of the simplest kind and is made with a light thatch. The structure having been completed, the whole is plastered with mud both inside and out and left to dry for a few days, after which it may be filled.

Cost of Construction.—The cost of construction is small, but will vary with circumstances. Thus a zemindar or cultivator to whom the materials are available for next to nothing could put up a silo such as I have described for from Rs. 50 to Rs. 100. For others, such as farms belonging to the Agricultural or Military Departments, it might cost from Rs. 150 to Rs. 200, according to the cost of labour and materials. The silo depicted in this article cost at Pusa Rs. 166, of which exactly half was the cost of material and the other half of the labour. The fact that it was being constructed experimentally and the labour paid for by the day, permits of the belief that with the knowledge of the details of construction acquired, it would cost very much less if given out on contract.

Filling the Silo.—The filling of the silo may be done in two ways. The material may be chaffed and lifted with baskets by coolies as depicted in Plate XV, beginning with the lower window, or an elevator may be attached to the chaff-cutter and the material raised automatically into the silo as depicted in Plate XVI. It should, however, be observed that the elevator should be longer than that in the picture and be able to reach the top of the silo. As the chaff is delivered into the silo either by the elevator or the baskets, men should be inside in order to spread the chaff and enable it to settle evenly. The more uniform the packing throughout, the better will be the preservation of the silage. The material should fill the silo above the brim. In a few days it will sink some four or perhaps five feet, when it should be filled up again and the operation repeated until sinking has ceased. Rapidity of filling does not, on the whole, appear to be important, but it is desirable that the material should be fresh. To cut maize or sorghum one day and place it into the silo the next is not to be recommended. It should be placed in the silo the same day it is cut.

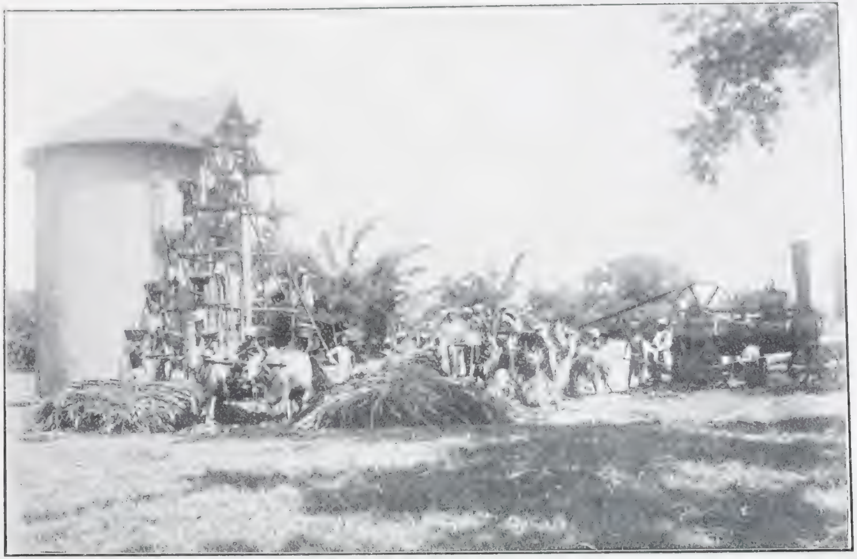
Crops for Siloing.—In the opinion of the writer, the best crops for siloing are either maize or sorghum. Other crops, such as millets, lucerne, grasses, etc., will make good silage, but the outturn obtained from these per acre is so small that they could not be considered the most economical. On the other hand, 200 to 300 maunds of maize and 400 to 600 maunds of sorghum can, without difficulty, be obtained per acre. In the case of well-manured fields, such as municipal lands, I have known very much higher yields being obtained. These heavy returns are not so easily obtainable with maize as with sorghum as it is a crop which has to be spaced in order to grow well; no spacing, however, is necessary for sorghum. An advantage which maize has over

PLATE XIV



A. J. I. WINDOW OF SILO CLOSED (*from outside*).

PLATE XV.



A. J. I.

SILO BEING FILLED BY COOLIES.

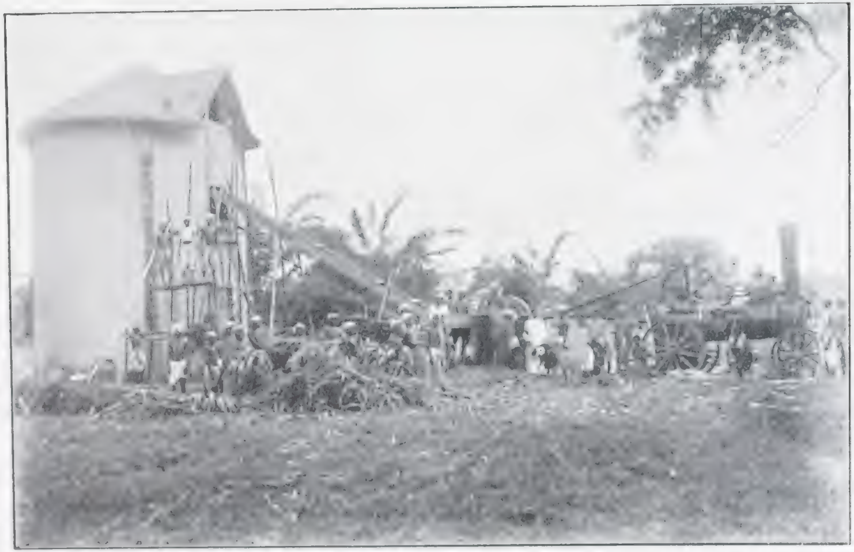
sorghum is that it is more nutritious if the cobs are allowed to get to the milk or dough stage, but it is doubtful whether this extra gain from its nutritiousness can compensate for the large yield per acre which can be had with sorghum.

Silo's Capacity.—The capacity of the silo described in this article is 6,096 cubic feet, but inasmuch as the contents will sink, the actual net capacity is considerably less. If, however, the silo is refilled after sinking as recommended in this article, 6,000 cubic feet may be taken as its greatest capacity. The weight of a cubic foot of settled silage varies with the depth of the silo and the part from which it is taken, but it may be taken as from 30 to 50 pounds, or say an average of 40lbs. per cubic foot. The contents of the silo would, therefore, be 240,000lbs. or 3,000 maunds if filled to its greatest capacity. From these figures, it should be easy to calculate the time such a silo would feed a given herd of Indian cattle for a given time. Let us suppose the daily allowance per head to be 30lbs. of silage, it would be possible to feed with it 8,000 head of cattle for one day or 44 head for six months. This calculation is made for full-grown animals. In a mixed herd of big and small, it may be taken as being able to feed twice that number.

Advantages of Silos.—The benefits from the siloing of green crops are many, but the following may be especially mentioned :—(1) Crops may be cut in any weather, unlike the making of hay or harvesting of corn which requires fine weather. (2) Crops can be stored and preserved in a green and succulent condition throughout the year and even longer. (3) Siloing is economical as it enables one to cut during the monsoon crops yielding very heavy returns per acre, such as sorghum and maize, and thus avoid the expensive practice of having to feed light winter crops such as lucerne, green oats, etc., giving but a small return per acre. (4) The bamboo silo described in this article is cheap considering its capacity and could well be made an easy means of storing fodder for times of scarcity, the cost of construction being only one-half anna per cubic foot of capacity.

Improvements.—It may be necessary to warn readers that the silo depicted in this article is not expected to last like a brick or wooden silo. What the life of the bamboo silo is, is a matter for experiment. The simplest form has, in the first instance, been constructed in order to ascertain the weak points. These will be sure to show themselves in the course of a year, when suitable remedies may be applied. It must, however, be remembered that where improvements have to be met out of current outlay, it is not always the most lasting thing which is the most desirable, although in the long run it may be the cheapest. The writer has known of cases where the more permanent structure was a distinct loss. Thus with the interest of the money which was required for erecting a corrugated iron roof, it was found possible to put up a new tiled roof every three years, though this was not actually necessary, for the latter with a slight expenditure in yearly repairs could be kept going for many years. And so it may be with silos. In a country like India where the agriculturist has no capital and a destroying climate, cheapness in construction is essential. The writer, however, anticipates that it will probably be necessary to give the bamboo silo a brick foundation so as to prevent rotting at the base. This and other matters will be taken up in a future article after experience has been gained.

PLATE XVI.



1. 2. 1 Silo being filled with Automatic Elevator.

THE "PAIRI" MANGO.

By WILLIAM BURNS, B.SC. (EDIN.),

Economic Botanist, Bombay

In the Bombay markets the mango most in demand is the *Alphonse*. This is a fairly well-known variety and has been distributed to most quarters of India, to the West Indies, to America and to Australia. Next to this famous variety, a much less known variety called the *Pairi*, has a large production and sale. Fig. 1 shows the typical Alphonse fruit, the left shoulder is high, the right low, and the beak is almost absent. In contrast to this Fig. 2 shows a typical *Pairi* fruit. Both shoulders fall about equally, and the beak is very marked. The shapes of both varieties are fairly constant and it is impossible to confound the two, once one has seen them side by side. The *Pairi* fruit when fully ripe has an external colour, varying from red on the shoulder to yellow at the beak. The flesh of this mango is of a brownish orange colour with very little fibre. The stone occupies perhaps one-third of the volume of the fruit. The taste is delicious, and slightly more piquant than that of the Alphonse.

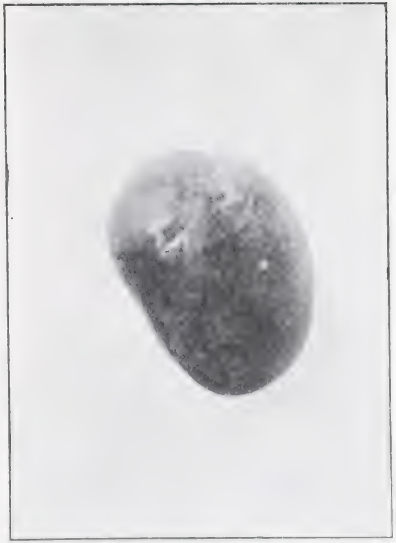
Some judge the taste inferior to that of Alphonse, but personally I prefer the slightly acid *Pairi* to the heavier and more luscious Alphonse. Woodrow gives the following weight and size of a typical fruit—weight 8 ozs., size 4 × 3 × 3 inches. One which I measured and weighed myself was as follows: weight 360 grammes, size 10·5 × 8·5 × 7 centimeters. It is therefore a moderate sized mango. There are several varieties with bigger and many with smaller fruits. The *Pairi* mango has one defect. It does not keep well. Whereas Alphonse may be kept up to two months even, if properly stored;

Pairi, with the utmost precautions, will hardly last 8 days. This character and its different flavour make it a cheaper mango than the Alphonse. In the Crawford Market, Bombay, when Alphonse mangoes are fetching retail round about Rs. 2 a dozen, *Pairi* mangoes usually fetch only Re. 1-8 a dozen at the outside. Their wholesale prices are similarly graded. I have been informed that in the season Alphonse will sell wholesale for Rs. 10 to Rs. 15 per 100, while *Pairi* will fetch only Rs. 8 to Rs. 10 per 100. The leaf of the *Pairi* mango is very typical of the variety. It is long, tapering, pale green, with a strongly marked white midrib. Such a leaf is shown in Fig. 5. (The scale in the figure is divided into centimeters.) The *Pairi* mango tree has a most vigorous spreading habit of growth and this is well shown in Fig. 4 where a tree of about twenty years of age is shown. This character of the *Pairi* makes it an excellent trunk piece for a composite grafted mango, giving a vigorous stem.

One or two sub-varieties of the *Pairi* mango are known, *e.g.*, *Moti Pairi* (Fig. 3), which is a larger kind, one specimen of the fruit which I examined weighed 527 grammes and measured 12 × 9·5 × 8 centimeters. Another sub-variety is the *Kagdi Pairi* (Kagdi-papery) so called on account of its thin and shining skin. The fruit is said to have firmer flesh and to be superior in flavour to the ordinary *Pairi*.

As regards the source and history of the *Pairi* mango little is known, but it is clear that it is of Bombay origin and has been little cultivated in other parts of India. Maries, in Watt's *Dictionary of Economic Products*, Vol. V, pp. 146–157, has one doubtful reference to *Pairi* which is worded as follows :—" I should advise planting seedling mangoes where grafts are difficult to obtain taking for the seed only such sorts as *Afooz Puary*, Kishenbogh, Durbhangah, Bombay, Fuzlee and good forms." In the portfolio of paintings of mangoes in the herbarium of the Calcutta Botanic Gardens I found no painting labelled Pairi. Firminger in the year 1874 or the more recent edition of his *Manual of Gardening for Bengal and Upper India* does not mention the *Pairi*. Two old Indian gardening

PLATE XVII.



A. J. I. Fig. 1.—Typical Alphonse Mango.

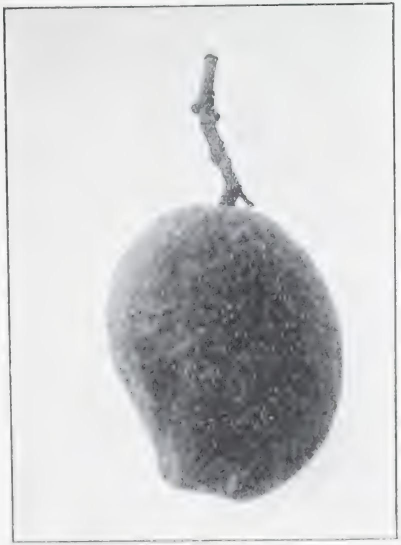


Fig. 2.—Typical Pairi Mango.

Negatives by Dr. Mann, Agricultural College, Poona.

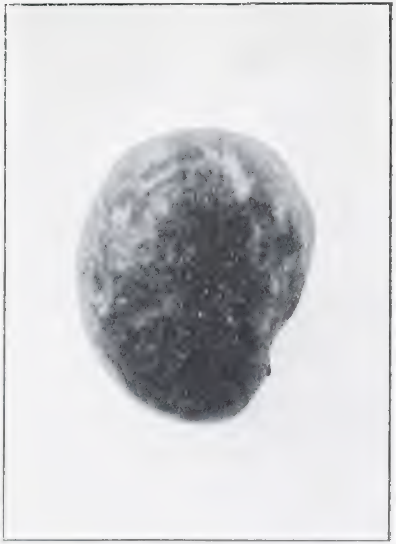


Fig. 3.—Moti Pairi Mango.

PLATE XVIII.

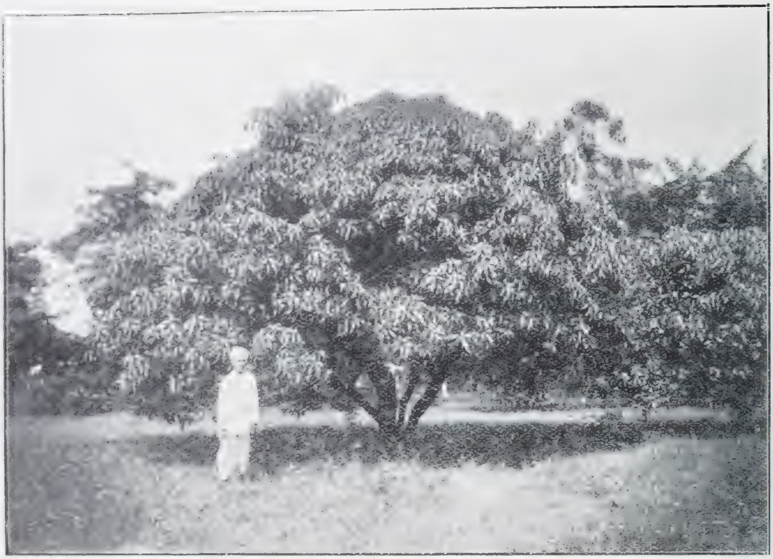
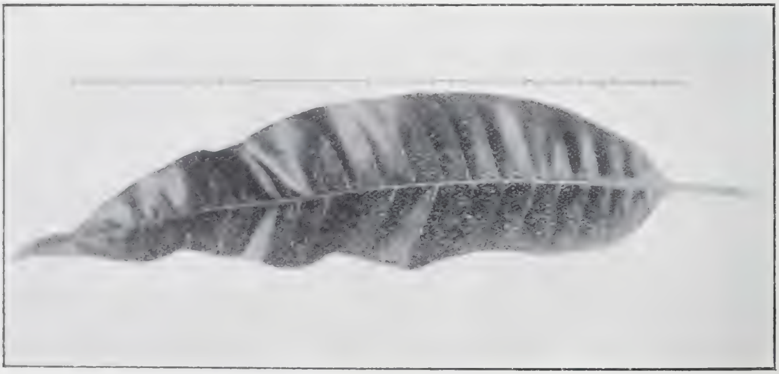


FIG. 4.—TYPICAL HABIT OF PAIRI MANGO TREE.



A. J. I.

FIG. 5.—LEAF OF PAIRI MANGO.

Negatives by **Dr. Mann, Agricultural College, Poona.**

books, Speede's *The Indian Handbook of Gardening* (Calcutta, 1842), and Pogson's *Indian Gardening in Bengal, Upper Provinces, and the Hill Stations of India* (Calcutta, 1875), make no mention of *Pairi*. These facts would seem to show it was for long unknown in Upper India.

On the other hand in a Resolution of the Bombay Government, Revenue Department, made in 1885, the following entry is made against Thana, "Afus and Pyre mangoes are largely grown in this District especially in Salsette." Cooke, in his *Flora of the Bombay Presidency*, 1903, Vol. I, p. 214, has a long note on the *Pairi* mango, mentioning its botanical and commercial characters. Gupte and Raje, in their Marathi book, *Krishi Karma*, 1901, p. 680, mention the *Pairi* mango and state that its name is a corruption of the Portuguese name Pereira. This is not impossible seeing that the Portuguese Alphonse has become corrupted into Apoos, Afoos, and Hapoos. In Woodrow's *Gardening in India*, 1894, pp. 253—260, *Pairi* is mentioned as one of the celebrated mango trees occurring in the following districts :—Poona, Kolaba and Surat.

All this would seem to show that it is a mango evolved probably by some Goanese horticulturist, but that it has somehow not spread over India or come to the knowledge of gardeners outside the Bombay Presidency to the extent that Alphonse has.

WHEN SHOULD MANURE BE APPLIED IN INDIA?

By J. WALTER LEATHER, Ph.D., F.I.C.,

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Two principles are acted on in the application of manure: the one being the most advantageous season to put it on the land, the other the most suitable crop to give it to. It is in relation to the former that the following suggestions apply.

Fertilisers, whether soluble in water before being put into the soil or not, must all become soluble before they are of service to the plant. Some, such as the "bulky" manures, farmyard manure, compost, refuse, indigo-seeth, and such like are in part soluble at first, and become more so as decomposition sets in: oil-cakes are similarly placed. Others, such as Indian saltpetre, chili nitre, or sulphate of ammonia are entirely soluble in water. Superphosphate of lime is soluble in so far as its most important constituent, calcium hydrogen phosphate, "soluble phosphate" is concerned. The finely ground rock phosphates, basic slag or bone-meal are so nearly insoluble in water that they are classed as "insoluble" though it is well known to the agriculturist that they must be so far soluble that they can serve the plant; otherwise they could not play the part they do.

But since such materials must be soluble in order to be useful, it is evident that the amount of water in the soil and the rainfall must have an important relationship to the employment of such materials. This factor has been recognised in Europe, but our Indian agricultural literature is without serious reference to it.

The problem is this. If we have a certain manure to put on the land, does it matter when it is applied, or must we select a particular month of the year or a particular season for the purpose? This largely depends on whether the material is "soluble" or not, because if it is soluble, heavy rain may wash it away from the region in which the plant-root development is taking place. For example, Aikman in his "Farmyard Manure" (page 43), says :—"As to the depth to which it is advisable to plough the manure in, it may be here noticed that it should not be too deep, so as to permit of the access of sufficient moisture to ensure proper fermentation, and to prevent rapid washing down of nitrates to the drains." And again in his "Manures and Manuring" (page 479), he says: "Nitrate of soda should never be applied before the plant is ready to utilise it" and "the use of such a fertiliser in a damp season is less likely to be economical than in a dry one." Such general principles are well known; the sentences quoted were naturally written for British farmers; they are simply an expression of the necessity for considering the current water supply as well as the nature of the fertiliser.

In India then it is important to apply these principles also. Since the fertiliser has to be brought into the soil at such a depth that it may be at the service of the plant, and yet be not washed away by drainage, consideration of the rainfall is the key to a right solution of the question. We may state it thus :—what rainfall do we require (if any) to wash our manure, or the soluble part of it, into the stratum of soil in which the plant is feeding, and what probability is there of it being carried too far down into the sub-soil?

In Europe the question is answered briefly thus :—bulky manures and oil-cakes should usually be ploughed into the land before the crop is sown, though some people put farmyard manure on the surface after the crop has germinated (*i.e.*, it is not ploughed in at all). Similarly the "insoluble" fertilisers such as basic slag or superphosphate are ploughed into the soil before sowing; but the very soluble materials like the saltpetre or sulphate of ammonia are more commonly broadcasted on the land after the crop has germinated; indeed when a crop is sown in the autumn such materials are not put on the land until the spring time because during the winter, plant growth is very slow and fertilisers are more useful in the spring time when growth is rapid.

This practice is based on the general rainfall. Broadly speaking this is distributed uniformly over the whole year ; each month receives its quota, rarely less than 1 inch, generally more. One inch of rainfall if it falls mostly within a few days in Europe is ample to wash a soluble manure well into the soil. It is probable that drainage would occur, but the fertiliser is not necessarily carried into the drains. When rain falls, for the most part it merely displaces water already in the soil (assuming no drought to have occurred) and some of the *latter* water finds its way into the drains. Even 2 inches of rain, falling within a few days, would not itself pass further than 12 inches deep, and in most cases it would reach a less depth than this. Hence it follows that in Britain it is quite safe to apply soluble manures, and even farm manure as a "top-dressing." Whether it would be equally good practice to put the former into the soil before sowing is another matter. Other considerations play a part. Not merely do we desire to prevent such materials from passing away in drainage water ; we must recollect that they may be lost to the plant in other ways, such as by bacterial changes. The latter simply make it generally desirable to present soluble manures to the plant as nearly as possible when the plant can use them.

It becomes then a question to consider in how far our Indian rainfall will indicate the most suitable mode of applying fertilisers. It will be most convenient to take the case of saltpetre first, because it is entirely soluble to start with, and will be carried with any water that happens to be present. Considering the two great divisions of crops, *rabi* and *kharif*, it is generally assumed that if saltpetre were used for the *kharif* it would be washed away before the crop could use it. Of the *possibility* of this happening there can be little doubt. For the sake of example I will consider the part of India where I reside—Behar. On the average between 5 and 10 inches fall in June mostly in the latter part, in July the mean fall is between 10 and 15 inches. Now at the close of the hot weather, and assuming the land to have been already ploughed a single fall of 5 inches would be all taken up by the soil and would distribute itself largely in the first and second or first to third feet. Under such circumstances it would be a mistake to put saltpetre on the land before the first rain. But the general practice is to cultivate the land during the first break succeeding the first fall of rain when the soil is nicely moist without being too wet and seed is sown on this. Supposing then that saltpetre were used at this time and 5 inches of rain fell some time in the next fortnight, it would be sufficient to displace the whole of the water in the first foot, and since this displacement is not perfect, some of it would find its way, may be, into the second foot. In this case also the fertiliser would be carried beyond the stratum in which the young plant wanted it, unless, indeed, the latter had developed unusually fast. On the whole, it would be an unsafe practice to sow saltpetre with the seed. But supposing the crop is allowed to grow, say, 6 or 8 inches high and the saltpetre is then put on, it is improbable that it would be carried beyond the stratum in which we require it. The root development will have extended beyond the first foot, the crop transpires at this stage probably 2 to 5 lbs. of water per sq. foot per day (·4″ to 1·0″), and unless the fall of rain succeeding the application of saltpetre were unusually heavy, such as 10″ on one day, or say even during three succeeding days, the fertiliser would be where the plant required it. I have assumed rather extremes throughout in order to show what both the possibilities as also the probabilities of the case are. Nor have I instanced the use of saltpetre as a top-dressing for a young crop in July in order to *recommend* it; it is probably more suitable for another season, but there would be no risk of the manure being washed away out of the area of the root range. So far as I can tell from my soil moisture records at present, "top-dressing" with saltpetre in Behar in July would be successful in most years.

We may also consider the case of Cawnpore. This soil holds probably about as much water as the Behar soil does. The following is a statement showing the fortnightly rainfall in the second half of June and the month of July for the last nine years; and an inspection of it indicates what the probabilities are of a soluble fertiliser like saltpetre being carried by heavy rain out of the reach of a young crop. In two years, 1904 and 1899, this risk would have been serious; but in the remaining eight years such a manure might have been safely used as a top-dressing.

Cawnpore.	June 15th to 30th.	July	
		1st to 15th.	16th to 31st.
1906	6·55	4·76	2·21
1905	...	5·62	2·52
1904	3·77	5·67	11·13
1903	1·72	...	0·77
1902	...	2·45	4·57
1901	...	4·66	2·99
1900	1·16	2·67	2·50
1899	5·50	4·85	15·52
1898	2·09	3·85	5·67
1897	1·20	0·94	5·02

We may turn to another example, namely, Dehra Dun. There the soil is generally stony, and although there are some areas of stiff land, the greater part would certainly not hold, per cubic foot, nearly so much water as the Behar soil; most of it would not hold more than half as much. Consequently any particular rainfall would displace water to a much greater depth than in Behar, and soluble fertilisers would pass correspondingly deeper. Add to this the fact that the rainfall is considerably heavier, and it becomes clear that in most years such fertilisers could not there be employed profitably to a rains crop.

We may next turn to the *rabi* season as exemplifying a rainfall characteristically different from the *kharif*. There is a general belief that such soluble fertilisers as saltpetre may be most economically applied to the cold weather crops. Such a belief is possibly sound. The average rainfall over nearly the whole of India from October to April is only a few inches and is generally insufficient to cause drainage; part of Eastern

Bengal and Burma forming perhaps the only exception. Consequently the risk of loss of such soluble plant food from this cause is nominal.

The question then follows whether the fertilisers should be ploughed into the land before sowing the crop or be put on as a "top-dressing." Taking Behar again as an example, the monsoon proper is expected to continue well into September and drainage does not usually cease until the end of that month. During October anything from 2 to 5 inches may be expected falling on an average of 2 to 5 days, that is, it is commonly fairly good rain. November and December are usually rainless. It follows, therefore, that if manures are to be used at all, they must be applied in October, and it seems clear that the proper course to pursue would be to plough them in with the last ploughing before the seed is sown. Top-dressing would in most years be useless, for the manure would remain on the surface, or at least diffuse into the soil only slowly.

Turning to Dehra Dun again the circumstances are different. October has its showers usually like October in Behar, but the temperature is so much lower during November and December that crops are held back and they mature fully a month later than in Behar. In addition to this there is nearly always some rain at the end of December or in January and fertilisers which had been put on the growing crop immediately prior to these rains would be sufficiently well washed into the soil to enable them to play the part they do in Britain. Thus, top-dressing for the *rabi* crop in Dehra Dun would generally be successful.

Another suitable example is the black cotton soil area in the Berars, taking Akola as a specific point. The land is "black cotton" soil and this will usually hold a fairly large *maximum* amount of water. The rainfall of this part is only small, *viz.*, about 30 inches; and this is distributed very uniformly over June, July, August and September; usually less than one inch falls in any of the other eight months of the year. Clearly then we may say it is useless to put a soluble manure on the land as a top-dressing during the "cold weather." If used for the *rabi* it would be necessary to plough it in before sowing. For the "rains" crops it is probable that it would be unsafe to put it on the land before sowing. It is true that when rain comes at the end of the hot weather the land will be so dry that the five or six inches of rain will be absorbed mostly by the upper foot of soil, but black cotton soil cracks so much that some portion of any heavy rain runs directly into the subsoil, and whilst an exaggerated idea exists regarding manures being washed away by rain, still in the case under consideration there would be a risk of some loss. On the other hand, if a soluble manure were scattered on the land after the crop had grown six inches or so high, the current rainfall of July should wash it into the soil; the hot weather cracks will be closed up by this time, and the usual rainfall would not be sufficient to carry the fertiliser out of the area in which the root development is taking place. Even a fall of two inches of rain at one time would do no harm in this respect, though one of four inches in one day might do so.

On the other hand, the same assurance could not be given for the neighbourhood of Nagpur where the soil is also "Regur." Appended are the rainfall data for the latter half of June and the month of July, and judging from this it seems likely that in six out of the nine years top-dressed saltpetre would have been largely lost to the crop.

Year.	June 15th to 30th.	July	
		1st to 15th.	16th to 31st.
1906	17·37	4·79	9·85
1905	5·1	9·79	2·50
1904 ...	6·3	3·90	0·57
1903	5·62	7·25	17·52
1902 ..	0·10	8·36	2 28
1901	4·84	1·04	6 92
1900	2·74	7·61	7·84
1899	4·00	1·68	1·56
1898	3·00	6·54	12·99

So far then as these very soluble fertilisers are concerned, it is purely a question of probable rainfall together with a consideration of the maximum amount of water the particular soil will hold.

I have been asked two questions in relation to possible loss of soluble fertilisers. The first is, supposing after *top dressing* with say saltpetre, a heavy fall of rain commences, such as ·2″ in the first hour, would any of the fertilisers be washed off the land? It is easy to show that it would not. We may take the following figures by way of illustration. Assume that the top-dressing has consisted of 500lbs. of saltpetre per acre; this is a much larger amount than one could usually afford to put on for a crop, but an extreme figure is purposely taken. Previous to this rainfall it is to be assumed that no rain has fallen for at least some days; otherwise the "top-dressing" would hardly have been put on. Since a young crop transpires very large amounts of water, it is clear that the surface soil cannot be saturated; hence it is equally certain that the first rain will soak into the land; it will be sufficient to assume that the first ·2″ is thus absorbed before any water commences to run off by surface drainage. Now 500lbs. per acre is equal to ·18 oz. per sq. ft.; ·2″ of water = 16 oz. per sq. ft., and since the ·18 oz. of saltpetre would readily dissolve in ¾ oz. of water, it is clear that the first ·2″ of rain (16 oz. per sq. ft.) is far more than is required to dissolve up the fertiliser; this water is indeed sufficient to carry the solution at least ½″ below the surface. If it is further recognised that there must be a downward movement of water taking place in the surface soil throughout the duration of the rainfall we are considering, it is clear that the nitrate having once entered the soil, it is perfectly protected from removal in any of the rain which may subsequently run off the field.

The second question which my friend put is in relation to "diffusion." I am not sure that the general reader of this journal will understand what this process is, but he may readily make an experiment which will demonstrate it to himself. Take a small teaspoonful of sugar in a glass tumbler and add ten tea spoonfuls of water. If the sugar and water are stirred together, the former will gradually disappear and *dissolve* in the water. We shall then have a solution of sugar. Now pour on to the top of this solution some clean pure water until the tumbler is nearly full. The water must be poured down the side of the tumbler very slowly and carefully so that it does not mix with the sugar solution any more than can be avoided. Now place the tumbler on a shelf where it won't be disturbed. At first the sugar solution will appear quite distinct from the water above it, but gradually in a few days it will be seen that the one liquid merges into the other and that the water in the upper part of the tumbler will become sweet. Thus the sugar has passed without any shaking or stirring from the one water into the other. This process is called "diffusion" and it occurs whenever a solution of a substance is brought into contact with some more of the same solvent.

Now the question which was put to me in relation to the possible removal of soluble manure, was this. Assume that the saltpetre is ploughed into the land before sowing, and that subsequently moderate though not excessive rain occurs, sufficient to carry the salt from the top 4″ of ploughed soil more or less into the first 12″. We would now have a solution of saltpetre in the first foot, but in the second and succeeding feet we should have either less or no saltpetre (there would probably be some saltpetre in the subsoil independently of that ploughed in). Diffusion would now naturally set in, and occasion some of the saltpetre to pass into the subsoil. My friend's question then is, would this process of diffusion be likely to occasion the removal of so much of the saltpetre from the surface soil to the subsoil and hence from the area in which the growing plant is developing as to seriously rob it? The information on the subject of diffusion of salts in soils is very limited, but it is a very much slower process than in plain liquids and I shall be safe in saying that not one-tenth part of the saltpetre could be thus lost to the plant.

Passing from these very soluble fertilisers to the insoluble ones such as finely ground bone, mineral phosphate, basic slag, it is clear that since they are so little soluble in water, they cannot be washed into the soil like sulphate of ammonia or saltpetre by heavy rainfall. The chief point to bear in mind in their use is that they should be as intimately mixed into the soil as possible. Accordingly it is an advantage to broadcast these fertilisers on the land at the commencement of tillage operations and give them every chance, by the repeated ploughings and cultivations that precede sowing, of becoming thoroughly incorporated into the soil.

Superphosphate, in so far as it is affected by rainfall, stands on much the same footing as insoluble fertilisers. Its chief constituents, the soluble phosphate of lime, is, as a matter of fact, perfectly soluble in water, but no sooner does a solution of this substance come in contact with the lime and iron in the soil, than it is rendered again insoluble and it is caught, so to speak, by the soil. Were it not for one factor it would be best to deal with it like the bone meal or basic slag, and bring it into as perfect intermixture with the soil by tillage operations as possible. But it is expensive, especially in India at present, and on this account a distinct advantage would lie in "drilling" it into the land immediately in front of the seed. It would then be carried by rain into just those parts of the soil where the young plant develops. Of course in many parts of India seed is not drilled but only broadcasted, and in such parts superphosphate also cannot be drilled.

The third great class of fertilisers are the bulky manures. There can be no object in making suggestions to practical men about the application of these. It is known from experience that they must be mixed into the surface soil some little time before sowing the seed where they become gradually changed into substances which the plant can assimilate. It may be of interest to some readers of this Journal to know that one part of such fertilisers is changed into the very soluble nitrate which we dealt with previously, and this can of course be carried away by drainage water. On the other hand, this nitrate is formed *gradually* and hence if a heavy rainfall occurs shortly after ploughing-in farm manure or a green crop, only that part of the nitrate which has already formed can be removed; a further part will be formed later on as the season progresses and some no inconsiderable part is reserved in the soil for future years.

THE PRESENT POSITION AND PROSPECTS OF COTTON CULTIVATION IN INDIA.—II.

(Presented to the Brussels Congress, May 1910.)

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(*Continued from page* 351, *Vol. V, Pt. IV.*)

II.—The Special Difficulties met with.

Mr. Mollison, Inspector-General of Agriculture in India, wrote two valuable notes on the improvement of cotton, one in 1902 and the second in the year following. To understand these properly it should be remembered that all previous attempts to improve the standard of cotton in India had been framed with the idea that there was no possibility of permanent improvement of any indigenous variety and that success could only be looked for in the introduction of some exotic already possessing the characteristics required. A renewed study of the problem thus brought prominently into view two main features, firstly, that there was not full information on record regarding the agricultural characteristics and comparative values of indigenous varieties, and secondly, that unsuccessful efforts have been made for many years to induce the Indian cultivator to grow exotics in order that finer lint would be produced.

In 1902 and succeeding years samples of indigenous cotton seeds bearing different vernacular names were obtained from all the provinces of India for sowing at Poona and other centres, and this collection in time formed a complete representation of the many types of cotton grown in the country.

A classification of these was attempted by the present Cotton Specialist. This was accepted as a handbook suited to the requirements of field-workers by most of the provinces of India, especially as it essayed no violent departure from any of the usually accepted methods of classification, its only novel feature being that it emphasised the necessity of subordinating botanical requirement to agricultural needs in the account of an Indian genus so highly domesticated that it is difficult to assert that any form exists in a truly wild condition in the country.

Having obtained a clear idea of the botanical characteristics of the cotton plant in India, the next steps were to judge of their comparative values from an agricultural point of view by seeing them grow side by side under varying conditions of soil and climate, and to determine how far the characters of a variety change by moving it from one district to another. The study of these questions in their entirety is obviously one that can only be completed after many years' observation, but by co-ordinating results obtained on the experimental farms throughout India, the following salient facts are more or less established :—

1. That long season cottons are quite unsuitable for early season cotton districts and *vice versâ*, and that slight differences of climate cause large differences in the quality of cotton produced.

2. That varieties characteristic of the black cotton soil fall away in some inherent quality if transferred to another class of soil.

3. That exotic varieties thrive better in red or sandy soils and have thus only been introduced permanently with varying degrees of success, outside the regular superior Indian cotton areas, *e.g.*, Dharwar American, Bourbon in Coimbatore, North Gujarat and the Konkan ; Egyptian in Sind ; Upland Georgian in the Punjab and United Provinces.

4. That inferior varieties are in many tracts ousting superior chiefly on account of their greater hardiness and more certain yield of a large outturn of cotton, and that the so-called deterioration of Indian cotton is really due to this *plus* the fraudulent practice of middlemen.

5. Good varieties from the first, when isolated, are superior to the remaining members of the general mixture too often found growing in the fields, *e.g.*, *Malvensis* in the Central Provinces and Khandesh and *Karungani* in Madras.

6. That, in rare cases, provided conditions are similar, a superior variety of the same type can be substituted with advantage, for instance, Broach cotton for *Kumpta* in the Dharwar District of Bombay.

7. That cross fertilization *inter se* has in many cases undoubtedly strengthened the stock, but the same method employed between different varieties has, up to the present, yielded nothing of permanent advantage. The reason for this can be gathered from the final paragraph.

8. In conclusion, the cotton plant is so influenced by its environment that in some provinces, for instance, in Gujarat, varieties which appear to be absolutely the same in every way from a botanical point of view have, nevertheless, individual characteristics which allow them to be grown in perfection and with profit only in the tracts where they have become the actual children of the soil.

As regards the chance of acclimatising exotics from which alone we can hope to produce cottons of sufficient merit to compete on equal grounds with that of America and Egypt, it is interesting to observe that Mr. Mollison's surmise (which is given in the next sentence) was practically sound and still holds good after seven years' further experience. He said : "Certain exotic cottons can, I am sure, be much more successfully grown in the alluvial plains of Upper India with canal irrigation than in the black cotton soil areas in Madras, Bombay, Berar and the Central Provinces ; and any real improvement of cotton in these black cotton soils can only be obtained *by working from within.*"

For many years past it has been considered that the problem of how to produce a high class long stapled cotton in India could be solved by the cultivation of one or other of the many foreign and naturalised varieties of Tree Cotton. In the time of the East India Company strenuous efforts were made in several parts of the Madras and Bombay Presidencies to establish Bourbon as a crop. Many experiments were made, some showed distinct indications of success at first, but all were in the end disappointing and now the plant exists as a mixture in fields in the red soil of Coimbatore and adjoining districts, and sporadic plants occur in many gardens throughout India and Burma. There is still room to hope that, with more careful selections of locality and the more progressive methods of treatment and cultivation, this variety may yet be found profitable to grow. Trials with Brazilian, Rough Peruvian and a few others have failed completely. The chief objections to the introduction of a tree cotton as a field crop are its urgent water requirement during the early part of its life which, of course, necessitates irrigation over the greater part of India ; the extreme likelihood of no crop being produced in the first year : the risk of the very brittle branches being broken by the wind : the increased danger from insect pests which are harboured and carried on from year to year ; the imperfect opening of the boll—a condition usually associated with a damaged state of the cotton ; and last, but by no means least, a low outturn throughout (as compared with that of indigenous varieties) or a fairly high outturn in the first year followed by steadily decreasing yields in succeeding years.

The greatest difficulty in the way of maintaining superior variety indefinitely, however, lies in the vicissitudes of the seasons. The greater part of the cotton tracts in India is certainly liable to recurring periods of famine. During these, the coarser types which are most resistent to drought, will usually yield something of a crop to the cultivators, while the finer may be hopelessly lost. In succeeding years the farmers, benefiting by a lesson gained through hard experience, carefully sow their fields with seeds derived from the surviving varieties. They may earn less than formerly from the produce of the cotton, but on the other hand, they are more certain of saving themselves from absolute loss. To give instances, the substitution of *Jari* for *Bani* and *Varadi* for *Jari* in the Central Provinces, and of *Mathio* for *Lalio* in Kathiawar, can be accounted for in this way.

Taking, as we perforce must, the climates and soils of India as they are and assuming that the whole area suitable for indigenous cotton cultivation is almost wholly occupied and that exotic cottons (with rare exceptions) have failed to maintain their footing in these, the outcome of a long grapple with difficulties leaves us, at the present moment, equipped with a slender amount of valuable experience which can be shortly summarised as follows :—In the indigenous cotton areas, as Mr. Mollison enunciated years ago, *improvement must come from within.* The results already arrived at in Bombay, Madras, and the Central Provinces teach us that much can be effected in a short period by following up this line alone. In the Punjab, United Provinces, Bengal, and on the lighter soils and heavier rainfall tracts of Madras, Bombay, the Central Provinces and similar regions throughout India, much might still be done in the introduction of one or other form of Upland Georgian if the officers of the Department could only contrive to devote a small portion of their well filled time to the working out of the problem.

III.—THE NATURE OF EXPERIMENTAL WORK IN PROGRESS.

In the Bombay Presidency experiments have been conducted for several years past to test the suitability of the following cottons in the various cotton areas ; Uplands, Cambodias, Buri, Tree cottons, indigenous cottons and hybrid cottons.

After extended trials it has been definitely proved that cottons of the Upland American type only thrive in a certain tract of the Southern Maratha Country at the southern termination of the Presidency. As the land at Dharwar was outside the most suitable tract, a piece of land has been obtained near the town of Gadag, and all serious work on the most promising American cottons was carried through there since last year. At Dharwar, when dry easterly winds blow in the month of December, the plants become badly affected with "red-leaf blight ;" at Gadag, it is satisfactory to learn that not even a trace of the disease was visible. The following comparative statement shows the valuations of the special American cottons cultivated at Gadag :—

Register No.	Name.	GINNING PERCENTAGE.		VALUATION IN Rs. PER CANDY OF 784 lbs.		REMARKS.
		Grown at Dharwar.	Grown at Gadag.	Grown at Dharwar.	Grown at Gadag.	
				Rs.	Rs.	
.	New Boyd's Prolific (manured).		38·95		257	Equal to Dharwar American.
..	New Boyd's Prolific (unmanured).		36·6		–	
...	New Allen's Long Staple (manured).		38·49	–	273	Much superior in class and staple to Dharwar American.
...	New Allen's Long Staple (unmanured).	–	37·28	–		
212E	Old Boyd's Prolific.	32·41	36·84	270	259	Dharwar—Much the same as No. 38E-BI. Gadag rather better than Dharwar American.
209E	King's Improved..	33·14	35·38	..	–	
211E	Allen's Hybrid	33·10	35·03	300 nominal	270	Dharwar—Long silky staple, the best of the bunch. Gadag—Staple much better than Dharwar American.
207E	Truitt ...	32·90	35·03		257	Quite equal to Dharwar American. Disappointing in staple and colour.
213E	Tata's Allen's Hybrid.	31·03	33·06	–		
38E-BI	New Orleans	29·80	32·56	270	259	Dharwar—Fine staple and good staple, but leafy.
...	Dharwar American	–	30·84	240	257	

Note I.—The value of good saw-ginned Dharwar, *i.e.*, the best class of this cotton free from any admixture, was worth fully Rs. 260 to Rs. 262.

Note II.—The samples valued were not from selected plants, but were of the general picking.

Note III.—Valuations received through the Imperial Cotton Specialist attribute a higher relative value to the last mentioned cotton in the above list grown at Gadag by about Rs. 13.

The appearance in the fields of all these Uplands shows conclusively that they are just as suited to the climate and soil as the long established Dharwar American, and it is to be hoped that the Agricultural Department will spare no pains to test them to the utmost on an extended field scale before finally arranging for an annual distribution of seed.

A form of Upland Georgian, received from Cochin China, and passing current under the name of Cambodia, has already given clear promise of a greater adaptability to varied conditions as it is immune from "red-leaf blight" even on the Dharwar farm, and its behaviour on a site selected in the more rainy and hilly western part of the Dharwar District goes far to show that it may succeed even there. This year it is contemplated to test it on tracts with a heavy rainfall to fully test its capability. At Poona, in the Deccan, under a rainfall of about 25 inches it has attained maximum growth with produce satisfactory in quantity and quality.

At present the following valuations have been obtained—see page 47.

At Surat Mr. Main says that Cambodia has been found to be the only exotic annual which gives any promise of successfully competing with Broach Deshi in Southern Gujarat. It yields up to 385 lbs. of seed cotton per acre with a ginning percentage of 40. At Dhulia in Khandesh, while the yield of Cambodia was only moderate, its cotton was valued nearly equal to that of Navasari.

Another cotton, very closely allied to this, introduced from Chutia Nagpur in Bengal, where it is known as *Buri*, also yielded fairly good results, but it must be admitted that it is decidedly more particular in its requirements, of which a higher rainfall may rank as being the most called for. In the Central Provinces it has attained distinction in *Bani* growing tracts where the rainfall of the last two years has proved sufficient for it, but in the Bombay Presidency it will certainly have to yield the premier position to Cambodia. At Dhulia in Khandesh and at Poona in the Deccan, its cotton has been valued as equal to Broach which is slightly inferior to that of Navasari.

Tree Cottons.—Many forms of these have been grown in the Bombay Presidency for years and the final consensus of opinion seems to be that the only two at all likely to be profitable are Bourbon and Soft Peruvian. They are both quite hardy, more or less immune to insect and fungoid attacks, but share equally in the drawback of requiring irrigation to tide them over dry

Register No.	Name of variety.	YIELD IN LBS. OF SEED COTTON PER ACRE.		GINNING PERCENTAGE.		VALUATION.		REMARKS.
		Dharwar.	Gadag.	Dharwar.	Gadag.	Dharwar.	Gadag.	
						Rs.	Rs.	
53E	Cambodia from the Philippine Islands	276	165	34·58	36·62	...	...	Not valued.
66E	Indo China	418	110	33·75	36·94	...		Not valued.
67E	Indo-China	545	130	35·89	37·25	270	260	Dharwar—Much the same as New Orleans (ante). Gadag—Rather better in staple than Dharwar American.
68E	Indo-China	375	{ 116 90 }	35·40	{ 36·83 35·20 }	...	...	
102E	Cambodia from Madras	724	70	38·43	39·28	...	...	——
......	Bengal Buri Cotton	228	165	31·09	33·66	280	...	Dharwar—Nice strong staple not so long as Allen's Hybrid (ante), but class better, and cotton has more bulk. Gadag—Not valued.

The first figures show the results on a manured plot, while the second refer to an unmanured plot.

Note.—The valuations received through the Imperial Cotton Specialist assign a higher relative value to No. 67E grown at Dharwar by about Rs. 15.

periods. In the light sandy soils of northern Gujarat they yield a moderate crop in the first season; over the greater part of the Deccan in the black soil country no return can be looked for until the second year. At the Guneshkhind Botanical Garden near Poona, Bourbon does not yield any cotton in the first season. In three succeeding years the yield was about 100 lbs. per acre valued at Rs. 300 per candy of 784 lbs., or equal to F. G. Navasari. This was from seed produced by acclimatised Deccan plants. Plants grown from seed obtained from northern Gujarat gave cotton which was valued at Rs. 25 per candy higher than F. Navasari cotton. In Bassein on the coast north of Bombay, the following general conclusions were drawn:—The Bourbon gives a crop during the first year; it thrives best in black soil; that cattle manured plots produce a larger outturn of seed cotton than pruned and unmanured plants. So far the Bourbon is the only form which has been subjected to field tests by farmers, especially near Deesa, and their experience proves that the plant fails in outturn. Experiments are, however, still in progress to find out whether or no a more satisfactory result can be obtained by more careful methods of cultivation and pruning. All that can be said at present regarding the prospects of tree cotton cultivation is that every endeavour to grow various kinds on a large scale has failed disastrously. At the Nadiad Farm in Gujarat it was found that the vegetable *Bhendi* (*Hibiscus esculentus*) grown in the Bourbon plots, covered the expenses of irrigation by the sale proceeds of its crop. At the Guneshkhind Botanical Garden near Poona, acclimatised soft Peruvian was considered to retain its native characteristics by competent judges who valued it at Rs 400 per candy or Rs. 100 more than F. Navasari.

Indigenous Cottons.—The possibility of improving these by selection has been kept plainly in view for some years, and some valuable experience has already been gained. In 1904, a specially good plant of Broach was observed and seed has been sown continuously since from this and its descendants. Last year an area of 7 acres was sown with this cotton. The yield varied between 500 and 600 lbs. per acre with a ginning percentage of 32·5, which is an advantage of ·85 per cent. as compared with the result from an unselected sample. At Dharwar, selection has been going on during the same period from the local cotton. As the object aimed at was quality, this has been secured at the expense of the ginning percentage which has fallen from 25 to 23·36 per cent. In Bombay one lesson learned is that within a variety the quality varies more or less inversely with quantity. The selected cotton was valued at Rs. 265 when ordinary *Kumpta* was valued at Rs. 248; at the same time cotton grown on Dharwar farm from Broach seed was valued at Rs. 270 to Rs. 275, with a ginning percentage of 30·62 to 32·81, so that the policy of the Department of encouraging the extension of cotton grown from imported Broach seed is economically sound. The fact that selected Broach grown at Dharwar in 5 years dropped in percentage from 32·81 to 29·51 proves the necessity of frequent imports of fresh Broach seed to check the inevitable deterioration which accompanies attempts at each acclimatization. At Dohad, in the Panch Mahals, it was definitely ascertained that no cotton, which did not yield before the end of December, could be successfully cultivated on account of the damage liable to be done by frost. Khandesh cotton yielded at the rate of 539 and 496 lbs. of seed cotton per acre, as the bulk of the produce was harvested before the frost came. Cambodia cotton, introduced from Cochin-China, also did fairly well. It yielded at the rate of 468 lbs. of seed cotton per acre before the frost occurred. It is unlikely that any other variety of cotton will succeed unless it is sown early in the year under irrigation. At Dhulia in Khandesh a prolonged study of the local forms has clearly established the fact that they consist of a mixture of at least six types and that some of these are better than others. The distribution of seed of the best type has already been commenced.

In the Southern Maratha Country, where the staple of the Dharwar American cotton varies from ⅝ to ⅞ of an inch, work in selection has been initiated, not only to improve the length of the staple, but also to fix a green seeded type which bears longer cotton with a ginning percentage of 1 to 2 per cent. higher than that of the white seeded variety.

Hybrid Cottons.—In spite of long continued and laborious study little or no progress has been effected in establishing stability in these and as a final resource the method of the unit system has been introduced. One general conclusion arrived at on the Surat Farm is that at least three of the hybrids are now equal to the best Navsari. Some crosses made between different kinds of Uplands at Gadag are yielding hopeful results. At Nadiad in northern Gujarat, some excellent crosses have been evolved between Texas and Bourbon and also between Egyptian and Sea Island and Bourbon. The purpose of the crosses was to remove the objection to Bourbon that its bolls opened badly causing weakness in the fibre. All the crosses made proved superior in this respect and the subjoined statement shows that the results are so far encouraging, see page 51.

At Dhulia hybridizing experiments have been conducted with the view of combining quality and outturn in the local cottons.

In the Central Provinces an experimental farm devoted mainly to the investigation of problems relating to cotton and *juar* has been started at Akola in Berar. There it has already been demonstrated that tillage causes the land to absorb and retain all the rain that falls on it. The separation and selection of the different types of *neglectum* cotton which exist in Berar have been carefully conducted and the variety known as *malvensis* has proved superior so far both as regards quantity and quality.

The most important fact, however, that has come to light during the course of these experiments is the suitability of a higher class cotton for the soil of Berar in Bani tracts, namely, *Buri*, an acclimatized form of Upland Georgian in Chutia Nagpur. This has been valued at 50 per cent. more than any of the local cottons. The chief drawback to its cultivation is that it may suffer more from drought than the local *Jari*, but still it may pay the cultivator to take the risk. Another step in advance which

Register No.	NAME OF HYBRID.	Area grown in 1908-1909 in gunthas.	Ginning percentage.	Yield per acre in lbs. of seed cotton.	VALUATIONS.			
					The Bombay Cotton Trade Association.		Through the Imperial Cotton Specialist.	
					Value in rupees per candy of 784 lbs.	Remarks.	Value in rupees per candy of 784 lbs.	Remarks.
1371	Texas Bourbon (35T) ..	10	24·2	753	260	"Rather dull in colour, nice staple."	300	"Navsari style of cotton."
1370	Do. do. (23T) ..	10	26·2	688	260	"Dull and stained but nice staple."	260	Ditto ditto.
1368	Do. do. (15T) ...	10	...	705	...	Not valued	..	Not valued.
1367	Do. do. (15T) ..	10	..	1,114	...	Ditto		Ditto.
1380	Abassi do. (21T) ..	5	26·5	216	265	Dull colour but very nice staple	350	"Egyptian style."

has been taken by the Department is the establishment of eight seed farms in tracts where they are immediately under the eyes of the cultivators. Here varieties which have been approved of in the experimental farms are produced in large areas and the seeds distributed to cultivators. At the end of year 1908-09, 8,245 lbs. of Buri seed had been distributed in Berar, 1,714 lbs. in the Central Provinces and 1,000 lbs. in the Feudatory States. The lowest outturn on the farms was 300 lbs. of seed cotton per acre and the highest 1,080 lbs. It was not affected by wilt and the percentage of cotton to seed was as high as that of *jari*. Its tolerance of a higher rainfall gives promise of success even at Rajnandgaon and Raipur. The cultivation of Buri by farmers who buy and sow the seeds is fortunately not left altogether to their discretion because the trained agricultural assistants who are in charge of the seed farms in Berar also supervise the operations proceeding in the districts.

In his manurial experiments on cotton, Mr. Clouston still finds an advantage in the use of a nitrogenous fertilizer in a manurial dressing. As regards rotation, it seems that cotton and *tur* in the first year and *juar* in the second and cotton and *juar* in alternate years are easily first, thus confirming the value of the local practice.

In the Akola Farm, owing to the abnormal character of the two seasons the farm has been in existence, some experiments so far have yielded negative results and others of a more obvious nature have confirmed facts, such as that as long as the number of cotton plants are not crowded, the larger the number the greater the yield. On poor soil, the cultivator does not thin out the plants at all but allows all to come to maturity. In a favourable year and in good soil, however, the growth of the plots is greatly increased and fewer can be grown with advantage to the area. Trials are in progress to ascertain the most profitable spacing distance to adopt on heavily manured soil.

Another series of trials laid down to ascertain the relative values of the outturns of different cottons have so far been discounted by adverse circumstances of which water logging was the chief. Under these unfavourable conditions, however, *Buri* surpassed all but Berar *jari*.

Samples of all these cottons were reported on by Khan Bahadur Bezonji, the Manager of the Empress Mills at Nagpur, as follows :—"Verum and Malvensis are good types of *jari*. The staple is rather fine and long for *jari* ; they would be worth about Rs. 5 more for *boja* of 345 lbs. Rosea and Cutchica are the useful types of *jari*, with fibre short and coarse. The Buri cotton is long in staple and better than Bani. The Upland Georgian may be considered equal to Bani."

The following is the statement of outturns as given by Mr. Clouston :—

No. of plot.	Name of cotton variety.	Outturn of seed cotton per acre in 1907-08.	Outturn of seed cotton per acre in 1908-09.	Percentage of lint.	Value of lint outturn.		
		lbs.	lbs.	lbs.	Rs.	As.	P.
1	**Malvensis** ...	240	224	32·16	30	11	6
2	**Verum**	182	274	32·65	38	14	6
3	**Roseum**	278	342	38·04	55	9	5
4	**Roseum Cutchica**	194	317	38·05	51	2	1
5	**Berar Jari**	255	429	38·16	69	7	1
6	**Upland Georgian**	84	370	29·00	49	11	1
7	**Buri** ...	77	426	33·06	66	4	1
8	**Bani** ...	151	246	26·78	28	8	10

It has always been a moot point whether topping the young plants is really beneficial or not. The Akola trials so far demonstrate that the chief difference between topped and untopped plants is that the latter throw out new branches and mature three weeks later than those allowed to grow naturally.

The series of experiments designed with the idea of gauging the profits to be derived from the use of fertilizers as manures for cotton grown on black cotton soil has already shown a few indications of result, such as that highly soluble artificial fertilizers are not profitable when applied without a more bulky organic manure, that when applied along with so bulky a manure as cattle dung, however, both nitrate of soda and nitrate of potash are likely to prove profitable manures ; that the nitrogen of nitrate of soda appears better than the same quantity of the nitrate of potash; that 10 lbs. of nitrogen in either form along with 64 maunds of cattle dung is more profitable as a manure for cotton than 20 lbs. of either fertilizer with 32 maunds of cattle dung. Another series of trials which may probably bring out a profitable idea for the farmer is to determine the comparative values of cattle dung and urine as manures for cotton, the urine being conserved by the dry earth system. Cotton and *juar* are to be grown in rotation and the manure applied every year. Mr. Clouston is certain that by adopting the dry earth system of conserving the urine of his cattle a farmer can double his supply of manure.

In the Madras Presidency, where well directed efforts have been persevered with for some years past, the Director has furnished a clear account of the work already accomplished and the following is the brief abstract of this.

In the matter of cultivation, in the Ceded districts where the use of the drill is universal, the only improvement calling for attention is the introduction of heavy iron ploughs already extensively used in parts of Bellary. Already, in spite of the extreme backwardness and conservatism of the Kurnool *ryots*, seven orders have been received for these ploughs, and their use is certain to spread as the value of the implement becomes established. In Tinnevelly, about 1,000 acres of privately owned land were sown with the drill, an entirely new introduction to this part of the Presidency. An inspection of the fields showed their superiority over broadcasted crops, as, the year being dry, the seeds were sown at an uniform depth and the soil moisture was conserved by frequent interculture. It is also asserted that sowing can be done more quickly by the drill. The *ryots* who have adopted the new method are fully satisfied as to its merits, and were more trained instructors available, the spread of the new system would probably be very rapid. The experiments in irrigating cotton at Hagari show that the yield of country cotton can be increased thereby in a dry season, but unfortunately not enough to cover the cost of laying out the land for irrigation and payment of water rate. In ordinary seasons there would be no advantage whatever. The *ryots* who enjoy the facilities offered by the Kurnool canal are said never to use the water for cotton. All attempts to grow superior varieties of cotton with the help of irrigation have failed.

In the northern parts of the Presidency, owing to the mixture of varieties, seed distribution on a large scale has not been possible. Certain information, however, has been received to the effect that the two varieties of white seeded cotton, Gadag and White Northerns, were adjudged to be superior in every way to the *Yerra-patti* (brown lint) and *Nallapatti* (black seeded white lint) which at present occur in the mixture known to the trade as Northerns.

Forty-five acres of land have already been taken up for growing seed of pure white seeded Northerns and the seed will be distributed. Ultimately it is intended to expand the line of work with a view to raising the general type of cotton produced in the district and maintaining it on a higher level.

In Tinnevelly, where the cultivators are more intelligent and also where only two types of indigenous cotton are grown—*Uppam* and *Karunganni*—the problem is simple and the more so because several experts have declared that *Karunganni* is superior to *Uppam*. It appears to be at least as prolific as *Uppam*. Seed distribution has therefore been taken up on a large scale and last year sufficient for about 8,000 acres was sown. During this year seed was grown on 263 acres of *ryot's* land for distribution by the Department. It is to be hoped that the proportion of *Karunganni* will increase in Tinnevelly cotton and hence give it an enhanced value.

In their attempts to effect the improvement of cotton the officers of this Department have learned by experience that better results are likely to accrue from selection of their local varieties than from the introduction of varieties from foreign countries or from other provinces in India or even from other parts of their own Presidency. Trials in the dry tract of Bellary distinctly prove that in a bad year no variety yet discovered will fare better than the local "Jowari." One great objection to it is its low percentage of cotton to seed, this being only 25, but selections made and partially tested already show over 30 per cent. A certain amount of attention is also being paid to the call from Indian mills for a longer staple cotton which will make the country independent of the American supply, and the study of Bourbon cotton, the only long stapled variety in the Presidency, is being taken up. At present it loses its value because it comes into the market mixed with a short stapled cotton.

A variety of *G. hirsutum*, known as Cambodia, is now being extensively cultivated in the Tinnevelly district on land commanded by wells. It is a risky crop to grow on dry lands, but it is expected that its introduction will prove a useful one. When the officers of the Department realise the possibilities inherent in this variety, they will make strenuous efforts to test it thoroughly, as it is perhaps the most promising cotton of Upland type ever introduced into India.

In the Punjab, although its Agricultural Department is one of very recent organisation, a few important details on the subject of the cottons likely to be of use in the province have already been established. Many of the American cottons have given very good results. Two varieties have already been selected to be tested on a field scale. The Buri variety from Bengal also promises well. The African varieties have been found to be too late in ripening to suit the requirements of the Punjab. Egyptian cottons fail when grown under local conditions and their chance of success seems very remote. Five varieties of indigenous cotton, fairly true to type, have been sown on large plots. Direct evidence has been found that cross-fertilization does take place in cottons. The tree cottons, as might be expected, produced no crop of any value whatever. A collection of Punjab cottons was made and the plants grown for botanical purposes. It was found that practically each of these was such a mixture of types that it was difficult to say which was the predominant one

As is the usual experience all over India, the excessive rains in the cotton flowering season caused a larger number of the early flowers to fall off and consequently diminished the outturn considerably.

In the Administration Report of the Director of Agriculture for the United Provinces of Agra and Oudh, a meagre account only is given of the progress of cotton improvement in his province. It is to the effect that 360 maunds of American acclimatised cotton were sold mostly in the Aligarh district. The season of 1908 was unfavourable to all kinds of cotton and the yield was very poor. The Department purchased such cotton as was brought to it and arranged for ginning and disposal to spinners. The future of the crop still seems doubtful. If sown early enough, it grows well and yields heavily, but the problem of getting it to market unmixed with country cotton and in quantities large enough to attract buyers is still unsolved.

These provinces of course yield the class of cotton known in the trade as "Bengals." There is little hope of ever improving these to a sufficiently high standard and it is a matter of regret that the officers of the Department do not realise the necessity of supplanting them by some form of Upland cotton for which the climate seems quite suitable.

In Burma, where the Department has not enjoyed sufficient time as yet to accomplish any thing definite, the Director states that the general unsuitability of the Lower Burma soil and climate for cotton has again been indicated. Before attempting to introduce exotics in Upper Burma efforts are being directed towards a thorough examination of the varieties now grown with a view to ascertaining the possibilities of improvement by utilising the best of them. A variety found in the Northern Shan States has obtained a very favourable report from a Bombay firm and is now being tried at the Mandalay Agricultural Station.

In Bengal, which lies practically altogether outside the great cotton tracts of India, an experiment with Buri, a variety of Upland Georgian acclimatised in Chutia Nagpur, has rather disappointed the officers of the Department, but further trials with this, the *Dishila* and the Bourbon will, I am certain, show them that cotton of good quality can be produced at a profit in Bengal.

In Eastern Bengal and Assam we have a striking instance of an abnormal variety of cotton growing under what we also consider abnormal conditions of climate. This cotton is grown only by the aboriginal hill tribes under a primitive system of agriculture, and it is so harsh in its nature that it is said to be used only in Europe as a substitute or adulterant of wool. Attempts to grow other varieties of cotton fail uniformly on account of the heavy rainfall. The variety grown in the Garo Hills is taken as the best of the hill cottons and trials with its seeds will probably be made throughout the hill tracts of the province in general.

FIELD EXPERIMENTS.

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A NUMBER of experimental farms have been established at one time or another in India, particularly in the more accessible parts of the country, where agriculture is already developed to a very high degree of efficiency having regard to the economic conditions under which it is practised; it is therefore reasonable to suppose that the more obvious improvements will shortly have been effected and the more obviously crude practices have died out, and that in future the margin of profit to be made by any departure from local practice will tend continuously to decrease. In proportion to this decrease will be the increase of the importance of pursuing scientific method on experimental farms, in order to estimate, as rapidly, certainly, and accurately as possible, the relative advantages of different practices.

For the purpose of such estimates, field-experiments may be broadly divided into two classes,—those that necessitate the comparison of the yields of crops, and those that do not. The latter involve little but care and actuarial calculations, and are not complicated by incalculable factors that give any special difficulty; whereas in the former, the whole range of physical and chemical differences of soil comes into play, and if the variation in fertility due to these differences is at all considerable, the usual methods of tabulating and comparing the results of comparative experiments are of very little use. In fact, judging from attempts that have been made, at points so far apart as Lyallpur in the Punjab and at Sabour in Bengal, to test the fertility of fields to be used for experiments, there is reason to suppose that this variation in fertility, within a short distance, is so great in some of the alluvial soils of India, as quite to obscure the results of comparative experiments, unless special precautions are taken to minimise and discount such variation. An account of these attempts, and of a system devised to discount the results, may therefore be of interest to workers in this field.

The plots in both cases were laid out so as to be of the minimum breadth compatible with ease of cultivation and of the maximum convenient size, on the obvious principle (followed in laying out the classical experiments on wheat at Rothamsted), that, while small local variations in the fertility of the soil will be neutralised by one another to an extent proportional to the size of the plots, any large general variation is likely to be gradual and continuous, and that therefore the probable normal difference of fertility between two small equal adjoining plots will vary more or less directly as the distance between their centres—that is, as their breadth.

At Lyallpur the plots were 220 yards long by 11 yards broad; the fertility of the land was tested in 1907, previous to the laying out of the plots, by dividing a standing crop of a uniform variety of wheat into small squares and weighing the produce of each. The variation in fertility from side to side of the field in a direction across the future plots was then plotted in a curve, as explained below and as shown in the diagram (fig. 1). This result was roughly tested and confirmed in 1908, and shows the great influence of the soil factor, which caused a variation in yield of about 20 per cent., in plots in the same field, and an average variation of about 3 per cent., in 11 yards when adjoining plots are compared. The plots at Sabour have been laid out similarly, but are of double the size, roughly 340 yards long by 15 yards wide; they have been tested for one year only by the growth of rape, with the result shown in fig. 2. The testing will be continued for a year or two, as some of the land is known to have been highly manured in the past, but it is clear that here again the variation in the soil would, in the absence of such definite information as will be obtained by successive testing, completely obscure anything but the most marked results of experiments.

How such variation is to be discounted is therefore likely to be one of the most pressing problems before those who try comparative field experiments in India, for in few cases is the land available likely to be approximately uniform, and time can not be afforded to reduce it to uniformity, even if that were possible.

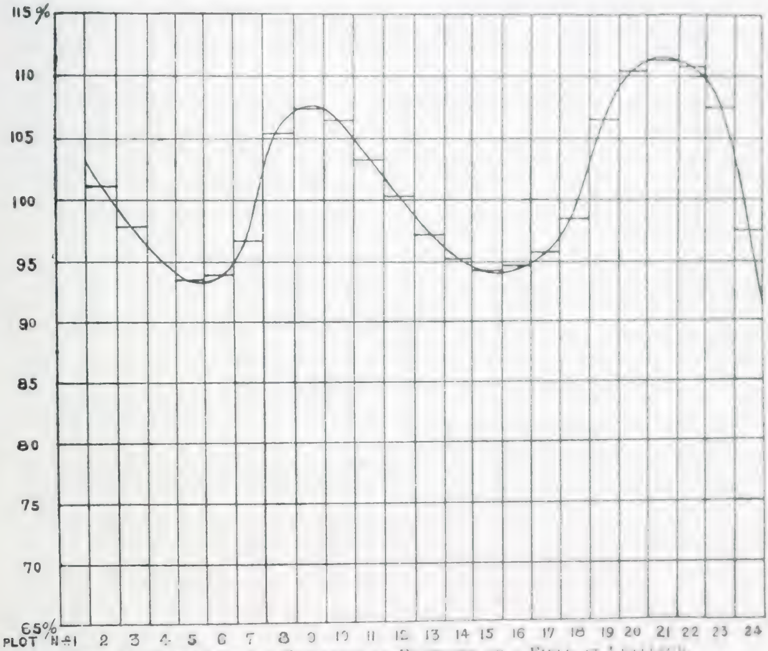

FIG. 1.—CURVE SHEWING VARIATION IN FERTILITY OF A FIELD AT LYALLPUR.

Looking at the diagrams given above, some of the principles on which the solution must depend become clear, *viz.* :—

1. Plots, the outturns of which are to be compared for scientific purposes, must be as long and as narrow as possible.
2. The differences of fertility of the plots should be tested before starting the experiments and taken into account in subsequent comparisons.

And in view of common experience of the manner in which the fertility of the land varies from year to year, according to its previous and present treatment, we may safely add—

3. The land should be tested again, every year, unless and until such tests may show that, owing to uniformity of treatment, progressive variation has ceased.

The last of these may perhaps seem difficult to put into practice, because it means that plots must be selected, at representative points on the curve plotted in the first year, and again normally treated every year, to the exclusion of experiments on those plots; but, until such testing has been satisfactorily finished, only plots that are alongside of one another can in any case be used for comparison, with any likelihood of reliable results, and there seems no reason why the experimental area should not be so laid out that every other plot should be always normally treated, being used as a "control" both for the experimental plot on each side of it and for the variation in fertility of the whole field under normal cropping. If this system increases the number of plots necessary to carry out a given number of experiments, it ensures, on the other hand, more immediate and reliable results than could be obtained by any reasonable amount of the duplication of experiments which is generally considered necessary to lessen the effect of the indeterminable factors which such a system eliminates.

An essential part of such a system is the "normal" treatment of the "control" plots. It is on all counts desirable that the progressive variation of fertility of the field as a whole should be brought to an end, and normal conditions established, as soon as possible. This implies that the whole field should be so cropped as to be reduced, or worked up, to fair fertility, and kept there. The work done at Rothamsted has made unnecessary the repetition of academic experiments on a field scale, and enables us to work within the ordinary canons of good husbandry; and there seems no reason why the area devoted to comparative experiments on a farm, should not be normally cropped with a standard rotation, compiled with regard to local practice, so as to be both conservative and profitable. Each year of the rotation would be represented on the land by one block of plots, uniformly cropped except for the experimental treatment given to every alternate plot. Every experiment which affected the fertility of the soil could be tried on corresponding plots in each block every year; other experiments as far as possible on different plots every year; and any practice found unquestionably profitable could be substituted for the "normal" treatment on the "control" plots.

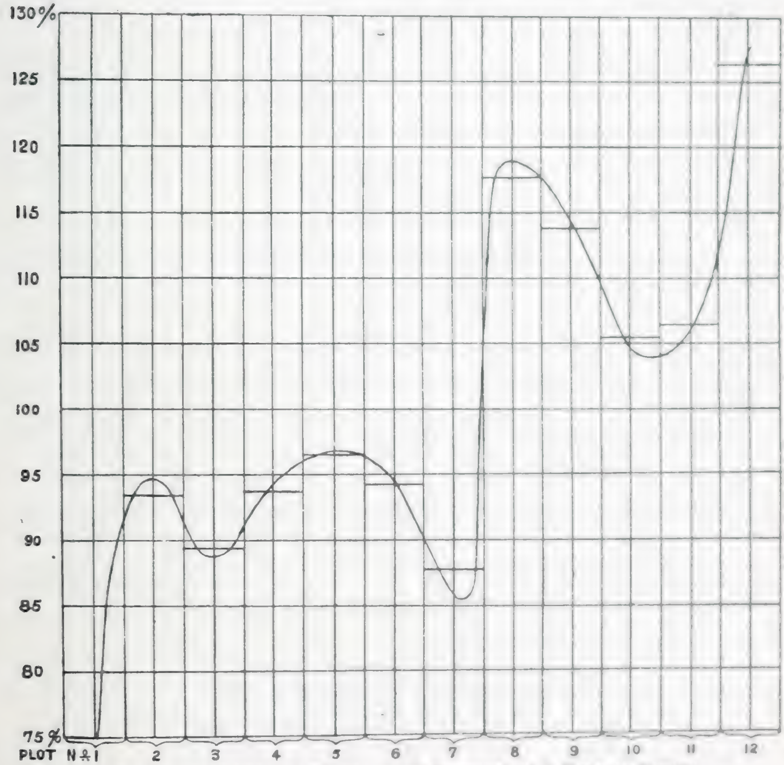

Fig. 2.—Curve shewing Variation in Fertility of a Field at Sabour.

Such a course has the immense advantage of providing a practical 'control' for every experiment, instead of its being made, as is too often the case, on the basis of some impracticable and unprofitable system such as the growth of several cereal crops in succession on the same land.*

As a concrete example, the experiments carried out at Lyallpur will serve to illustrate a method of estimating the results of experiments planned on such a system as is here suggested; it is not an example to be followed because the experiments were complicated far more than was desirable, in order to test some manures, information regarding which was urgently required: but it is perhaps all the more useful as an illustration.

The fertility of the field was tested in 1907 and gave the curve of fertility, shown in fig. 1, and reproduced as the black line in fig. 3. The following method was used to plot this curve:—Up and down lines are taken to represent divisions between equal narrow plots in the field; a cross line in the middle of the paper is taken as a base line, representing the average yield per acre of all the plots, and is numbered 100. Percentages above or below this are marked according to any convenient scale on the marginal lines.

The yield of each plot, calculated per cent. of the average, is now marked by a line parallel to the base line across the plot, at that percentage.† Now if the width of the plots could be indefinitely decreased and their number similarly increased, and if no abrupt difference of soil or treatment occur in crossing from any one plot to the next, these lines would ultimately merge into a continuous curve, showing the gradual variation of fertility of the field from side to side in a direction at right angles to the plot boundaries.

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* The Rothamsted experiments have shown us both what to do and what not to do in this respect; they are, for the most part, incapable of direct application, in practice, because the "control" provided is, purposely, a system which exhausts the land; and it is hardly too much to say that the value of nitrates has probably been considerably exaggerated, in England, owing to the omission on the part of the public to take this fact into account.

† The actual plots used for this purpose were not those shown here, but the curve shown having been plotted for this field from the original materials, not now available, the estimated yields of the new plots laid down in 1907 have been marked for purposes of illustration. In fig. 2, the actual percentage yields of the plots at Sabour are marked in blue and that figure will perhaps serve better as an illustration of how the curve is actually drawn.

This curve, as will be seen subsequently, is the key to the interpretation of the results obtained on the plots, and it is therefore important to plot it carefully. But as, in practice, the width of the plots cannot be decreased beyond a certain limit, it is necessary to obtain the curve by estimation.

The yield of each plot tested is therefore marked, as stated, and the curve is sketched in, care being taken that it makes equal areas on opposite sides, with the line denoting the yield of each plot and the sides of the plot.

This curve shows the variation in fertility of the field for wheat in 1907. The curve for another crop or another season might be entirely different, and there is no doubt that the preparation of a series of these curves, for the same field under different crops, and for several seasons, would throw a most interesting light on soil and crop problems, particularly if compared with charts of the meteorological conditions, and of the physical composition of the soil.

But meanwhile, for the immediate purpose in view, it was necessary to assume that the curve was to some extent independent of seasons, and to trust to the test plots for any evidence to the contrary. Normal cropping, under a rotation intended to be permanent, was therefore begun in 1907-08. It was desired to test five samples of wheat while at the same time re-testing the fertility of the land and trying the effects of nitrate of lime and of calcium cyanamide on wheat. Under the somewhat elaborate 12 years' rotation selected, plots 1, 2, 3, 4, 5, 6, 13, 14, 15, 16, 19 and 20 fell under wheat.

It was decided to use these plots in the following manner:—

(1) All the odd numbers to be control plots, sown with a standard sample of wheat, for comparison with the outturn of the five samples of wheat, sown in the alternate plots.

(2) Plots 1, 5, 13, and 19 for re-testing the land.

(3) Plots 3 and 15 for the manurial tests.

(4) The even numbers for the five samples to be tested, one sample being sown in duplicate plots.

Plots 4 and 16 were given the same manurial applications as plots 3 and 15 respectively, so as to make a direct comparison between 3 and 4, and between 15 and 16 possible. When the results came to be interpreted, it became evident that several mistakes had been made in the planning of the experiments. Firstly, the rotation was too complicated, separating, as it did, the plots under wheat, and thus doing away with the advantage of having a control plot on each side of every experimental plot. Secondly, the manurial experiments should have been substituted for two of the sample tests instead of being superimposed on them. Thirdly, more plots should have been reserved for re-testing the fertility; and in particular there should have been one at each extreme point of variation, whereas plot 15 received calcium cyanamide, and therefore gave no check on any progressive variation in relative fertility at one of the least fertile points. As it happened, the results of plot 1 had to be rejected owing to the depredation of sparrows along the margin, and thus the actual yields of only three plots were left to check such variation. Fortunately the sample sown in plot 2 was the same as that sown in plot 20, these being the duplicate plots referred to above and so it was possible to estimate the probable yield that the standard sample could have given in plot 2 from the actual yields of plots 2,19, and 20.

These mistakes and accidents make any interpretation of the results more difficult and ambiguous, but not impossible. To attempt an interpretation, a diagram is prepared as shewn in fig. 3. The 1907 curve is first transcribed. The yields of the test plots in 1908, *i.e.*, of plots 5, 13 and 19, calculated as per cent. of their average yield, are now marked as shewn in blue. Plot No. 1 being out of court, the yield of the standard sample is estimated for plot 2 as suggested above, and marked with a dotted line in percentage of the same average. The curve of probable fertility for 1908 is now sketched in, the limiting conditions being :—

1. That it should be as far as possible conformable to the curve of 1907.

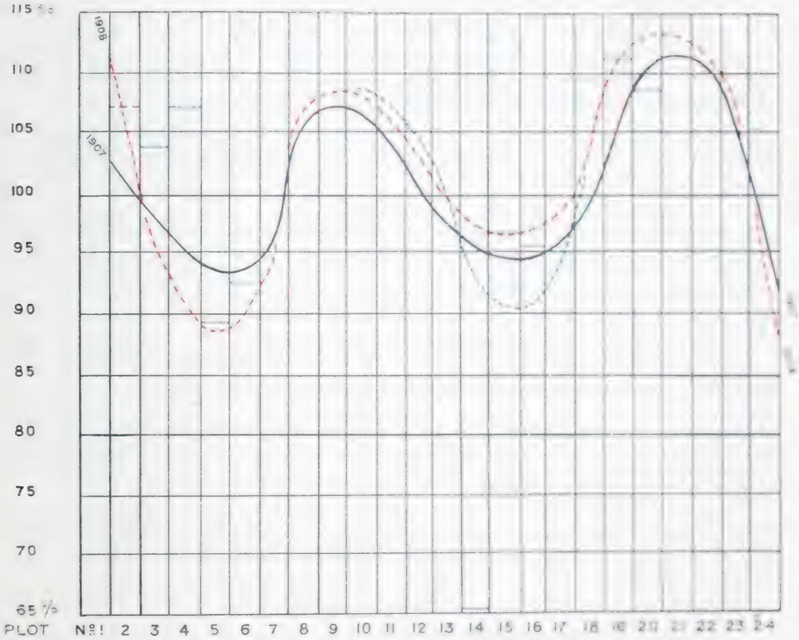

FIG. 3.—DIAGRAM TO ASSIST IN DISCOUNTING THE VARIATION OF FERTILITY IN INTERPRETING THE RESULTS OF EXPERIMENTS.

2. That it should cross the test plots so as to make on opposite sides, equal areas with the sides of each plot and the blue line representing its yield for 1908. This curve, shown in red in fig. 3, is dotted where it crosses plots other than the test plots.

The actual yields in 1908 of all the other plots, calculated per cent. of the same average, are also shown in blue.

The results now become relatively clear. To begin with plot 3, the yield would, but for the nitrate, presumably have been where the dotted red curve crosses the plot, and the space between this and the blue line represents the percentage increase due to the nitrate—about 8 per cent. of the yield of the plot.

In plot 4, the combined increase due to the sample of grain tested and to the manure is represented by the corresponding space and is about 16 per cent. of the average yield of the test plots.

The actual yield of the plot was 107 per cent. of this basal average, and the gain due to the nitrate being presumably 8 per cent. of the actual plot yield, or 8½ per cent. of the basal average, 7½ per cent. of the 16 per cent. is left as probably due to the difference of sample.

As the yield of the plot, after deducting the 8½ per cent. due to nitrate, is 98½ per cent. of the basal average, the 7½ per cent. due to the difference of sample may be taken as per cent. of the yield of the plot after making allowance for the nitrate.

These somewhat unsatisfactory and complicated calculations are necessitated by the superimposing of two experiments on the same set of plots.

Coming now to plot 6—the result shows a difference of about 2 per cent. in favour of the sample tested in that plot.

In plot 14 a difference of about 32 per cent. in favour of the standard sample, is accounted for chiefly by the fact that the sample tested was a broad-leaved durum wheat which is known to require much more water than ordinary wheats, but which was given the same amount as the rest.

On plot 15 the effect of the calcium cyanamide, which was applied late, appears to have been nil; but, taking into consideration the depression of the 1908 curve at plot 5, which plot crosses a patch of "kalar" land at its centre, and in view of the fact that plot 15 crosses a similar patch near its centre, it is doubtful whether part of the lowness of yield of plot 14 was not due to an increase of "kalar" salts, such as has apparently taken place in plot 5, and whether plots 15 and 16 were not saved by the manure from participating in such a decrease.

If plot 15 had been a test plot in 1908, the curve for that year might have shown a depression at that point, as suggested in the dotted green curve, similar to the depression at plot 5; the mistakes alluded to above are responsible for this ambiguity.

As regards the remaining plots, plot 16 shows a difference of about 2 per cent. and plot 20 of about 4 per cent. in favour of the standard sample of wheat.

On the whole, these results are remarkably in accordance with what was to be expected. Considering the demonstrated variation of 20 per cent. in the fertility of the plots and comparing these results with those of the experiments of many previous years as given in annual reports of the Lyallpur Experimental Station—experiments carried out by the same subordinate staff but, interpreted without the aid of any test of fertility—these results show a conservatism which is in itself an argument in favour of giving some such system a trial wherever the results of experiments involving the comparison of crop yields may, hitherto, have appeared unsatisfactory.

REPORT ON JUTE AND FLAX EXPERIMENTS DURING THE PAST YEAR.

By R. S. FINLOW, B.SC.,

Fibre Expert to the Government of Eastern Bengal and Assam.

I.—JUTE.

Cultivation of Pure Cultures.—Up to the commencement of the present year, the main portion of the work on jute was devoted to a study of the types of plant which are cultivated for the production of fibre. This stage of the work may now be said to have been brought to a conclusion and a short summary will not be out of place. It is, of course, well known that there are two botanically distinct varieties of jute, *viz.*, *C. capsularis* and *C. olitorius*; but, included under each of these main heads, are a large number of races, which it was necessary to classify and compare. Extensive tours, made throughout the jute-growing districts of Bengal and Eastern Bengal by Mr. I. H. Burkill, the Reporter on Economic Products to the Government of India and by the writer, showed that several types of *C. capsularis* each of which is generally known by a distinctive name are cultivated in each district and the result of this preliminary enquiry was that seed of over one hundred races or types was collected and sown in plots at Pusa. It was found by examination of these plots, that the seed samples of many races were very mixed and that many of the plots contained not one but several types of plant. The races had, therefore, first to be purified by selection before any real comparisons could be made between them. This portion of the work was rendered easier than it might have been because it was found that, in almost every case, the seed of each type of plant produces plants similar to the parent. This is due, as is shown below, to the fact that jute in the jute districts is normally self-fertilised. Nevertheless, the work required great care; because it was found that the races differ not only in colour, but also in time of maturing; so that a plot which appears quite uniform in the early stages of growth might ultimately prove to be composed of types of plant which differ considerably. After this process of selection had been carried through, it was found that many of the races, although passing under different names in different districts, were to all intents and purposes identical and the number of distinct types was ultimately reduced in this way to about 15. This represents the end of the first stage of the work, as a result of which we were placed in possession of fairly pure specimens of practically all the races of jute in Bengal.

The races of *Corchorus capsularis* present three distinct types of colour of stem, *viz.* :—

(a) Deep red.
(b) Russet red.
(c) Green—I (with green fruits).
II (with reddish fruits).

Under each colour-head, there are early and late maturing races. It has been noted that the late maturing races are generally taller than the early maturing ones; so that the former are likely to produce heavier yields of fibre than the latter. All these characteristics are hereditary and we are able therefore, in distributing seed, to do so with due regard to the conditions under which the crop is to be grown.

Side by side with this field work an investigation of the chemical and microscopical characters of fibre samples obtained from each of the respective races of jute is being carried out, the object being to determine whether or not any one or more of the races could be distinguished from the others as producing fibre of a superior quality. The natural outcome of this portion of the work should be the elaboration of a method of plant to plant selection for the production of a superior race of jute. Such methods, as is well known, have yielded markedly successful results in the case of crops like wheat, sugarbeet, etc. The difficulties which confront us in this work, however, are considerable, partly because of the fact that the fibre which we wish to examine is a part of the structure of the plant. It is obvious, for instance, that if the plant be destroyed, as is usual, in order to obtain its fibre, no seed could be obtained to sow, in case the examination of the fibre indicated superiority. Such a difficulty does not exist in the selection of cereals. Another difficulty is that, as far as we can ascertain, excepting cotton, the selection methods for which would probably not apply in this case, no other work has hitherto been carried out, having for its object the improvement of a fibre crop by direct selection. The progress has, therefore, necessarily been slow. We have, however, noted small but distinct differences, both chemical and microscopical and seed from each of the plants examined, the respective fibres of which have shown any indication of superiority has been sown separately in each case. An examination of the progeny is now about to take place. Whether such differences as these are intrinsic in the plant or whether they are mere accidents, of environment for instance, is a matter which only further observation can decide. It remains to be said that the selection work is laborious, depending largely as it does on microscopical measurements. An indication of its nature may be gathered from the fact that, in the selection of about 30 plants, it was necessary last year to make something like one hundred thousand actual measurements, under the microscope, of the tiny ultimate filaments, by the cohesion of which the long strand of fibre is produced.

Cross-fertilization Experiments.—The first of these interesting experiments, commenced in 1908, have now advanced as far as the second generation of the hybrids. They were designed to throw light on the nature of the origin of the different colour types of plant, already enumerated, which have come under our notice. It is not necessary to go into details here, but it may be said the result of crossing a pure green race of jute with a deep red coloured one has been to indicate :—

(1) That the colour of the stem in jute is a Mendelian characteristic.

(2) That jute is normally self-fertilised ; so that (a) an improved race if introduced would not be in serious danger of being speedily swamped by free crossing with inferior races. (b) In comparing one race with another, it is not necessary to take any special precautions to prevent contamination of the one race with the other.

It may be possible in the future to extend this work in various directions.

Jute in the Chittagong District.—These experiments originally commenced to investigate the possibility of the successful cultivation of jute in Chittagong have progressed so far as to show that excellent jute can be grown on high lands. More recent experiments have been devoted to utilising the low rice lands for jute in the period between the reaping of the one paddy crop and the planting of another. In 1908 sowing in April was unsuccessful, owing to the water-logging of the land. This year the land was ploughed in early January, as soon as possible after the paddy crop had been reaped and sowing also took place in January. The crop germinated evenly and looked promising in the middle of April. A long drought followed, however, and the seed being that of an early race, the plants matured prematurely ; thus spoiling the crop.

It is proposed to repeat the experiments next season with a later race ; the experiments are not very costly and they are yielding useful information regarding the habit of the jute plant ; moreover, a successful result would be applicable far outside the Chittagong district.

Bombay.—In 1909 a crop of jute at Belgaum yielded fibre at the rate of 1,570 lbs. (19·5 maunds) per acre valued at Rs. 6 per maund. The expense of production was, however, so high as in the opinion of the Deputy Director of Agriculture to preclude the possibility of growing this crop at a profit in Bombay.

Central Provinces.—Jute was grown successfully with irrigation last season at both Raipur (Chhattisgarh) and at Telinkheri (Nagpur). This year's crops are also satisfactory and the Deputy Director of Agriculture considers that there is now no difficulty in producing excellent crops of jute at the above experimental farms. It is interesting to note that *Corchorus olitorius* seems to thrive better, on the whole, in the Central Provinces, than *Corchorus capsularis.*

Distribution of Seed.—During the present season, 70 maunds of jute seed have been sold and above 20 acres have been put under various races of jute on the Dacca farm for the production of pure seed to be distributed next year.

II.—Flax.

Experiments at Dooriah.—This crop continues to be cultivated at Dooriah, Behar, on a considerable scale; but although nearly 40 acres were devoted to flax in the *rabi* season of 1909-1910, the experimental stage can hardly yet be said to have been passed. Last year's results, while indicating that the lower lands (*dhandhar*) are likely to prove most suitable, owing to the better supply of moisture, also tend to emphasise the necessity for high cultivation. Such lands which had been treated with indigo refuse yielded an average weight of nearly 54 maunds of excellent straw per acre. On the other hand, from similar land not directly manured rather less than 30 maunds per acre was obtained. The straw will yield fully 10 per cent. of fibre worth £50 or more per ton; so that the gross outturn on the manured plot was increased by manuring to the extent of nearly Rs. 60 per acre. Such a result indicates the necessity for careful investigation of the question of manures, and as there is at present no suitable land for the purpose on the Dacca farm, the Inspector-General of Agriculture in India has kindly offered facilities at Pusa for a comprehensive series of experiments, and has also given his advice in the drawing up of the scheme.

Experiments at Pusa.—The main object of the experiments with flax at Pusa during the season 1909-10 was to obtain information regarding the yield of straw to be expected from average good soil which had not been specially heavily manured for the crop. The land on which the experiments were carried out was high and rather light in texture; but it was in good condition and owing to the abnormal monsoon, the soil moisture was fairly good throughout. A yield of nearly 54 maunds of good straw was obtained from one and a half acres, representing 35 maunds per acre. Although this yield is satisfactory, yet the crop showed indications of distress at one time and the conclusion to be drawn is that in an ordinary moisture year, good results could not be expected from such high land unless irrigation were resorted to.

Further information was obtained on the subject of acclimatised seed, which indicates that new seed should be imported at least every two or three years if the quality of the fibre produced is to be kept up. As flax seed imported from Europe costs about Rs. 15 to Rs. 20 per maund, preliminary trials have been commenced in some of the cooler hill tracts of India with a view to investigating the possibility of surmounting this difficulty. As might be expected, no definite information has as yet been obtained; it is necessary first to ascertain the period of the year which is most suitable to the growth of the crop. Definite trials with this end in view are being carried out in the Shillong district by the Deputy Director of Agriculture, and seed has also been sent to Kashmir and to Ootacamund.

The Importation of Flax Seed from Europe.—In last year's report, reference was made to the fact that flax seed cannot be imported safely into India during the hot weather and the rainy season, unless special precautions are taken to dry the seed before despatch and to keep it from absorbing moisture during transit. Our experience has been that no special precautions are necessary, if the seed is despatched from Europe so as to reach India during the cold weather season. The total cost of importation under these conditions is from Rs. 15 to Rs. 20 per maund. If, however, the seed arrives during the hot weather, or in the rainy season, it is necessary to dry it very thoroughly before despatching and also to pack it in hermetically sealed tin-lined boxes; otherwise the seed after absorbing moisture ferments to such an extent that it refuses to germinate on arrival. A large consignment of flax seed was actually imported in tin-lined boxes during the rainy season a year ago and the bulk of it was good; but its total cost approached Rs. 30 per maund. Such a price for seed means a very serious increase in the working expenses of a crop, the seed rate for which is over one and-a-half maunds per acre.

Flax in Assam.—Mr. H. J. Lawrie of Baihata, Kamrup, made a preliminary trial with flax during last season, but although the straw was of good quality, the land on which it was grown was too high and the lack of soil moisture affected the yield adversely. It is hoped to continue the experiments this year under better conditions.

United Provinces.—Last season an excellent crop of flax was grown under irrigation on a demonstration plot at the Agricultural College, Cawnpore. The weight of straw, the quality of which was very good indeed, corresponded to 40 maunds per acre. Further trials are contemplated for the coming season.

Central Provinces.—A small plot of flax was grown last year under irrigation at Hoshangabad and produced straw of fair quality. It is proposed this year to carry out trials on the linseed growing lands in the Jubbulpore District and also in the Nagpur District.

Extraction of Fibre from Desi Linseed.—Several attempts have been made to extract fibre from the stems of ordinary linseed; but although linseed and flax are botanically identical, the two plants differ so greatly in their natural habits that very little success has hitherto been met with. While the straw of good flax is smooth, unbranched and flexible, the stem of ordinary linseed is generally rough, woody, brittle and often very branched. The fibre which can be extracted from such stems is not only very small in quantity; but it is also so inferior in quality as to be almost worthless. Last year, however, one crop of *desi* linseed grown on heavily manured land under good moisture conditions showed a distinct improvement in the quality of the straw, which weighed nearly 40 maunds per acre, while the seed obtained approached three times the quantity produced by the imported flax. The experiments will be repeated.

Conditions necessary for the successful Cultivation of Flax.—The following points in connection with the cultivation of flax are tentatively regarded as having been elicited from the experiments so far carried out in India.—

(1) Land selected for flax should contain an abundance of moisture both at the time of sowing and throughout the period of growth of the crop. If these conditions cannot be secured by natural means, irrigation may be substituted without detriment.

(2) Lands of the lower type such as *Dhankhar* are eminently suitable, both on account of the nature of their soils and also because the moisture supply is less likely to be precarious. There is, however, no doubt that flax will do well in high lands of good quality, provided the texture is not too light and that a sufficiency of moisture is secured.

(3) Sowing can usually be done successfully between October 20th and November 13th.

It would appear that the crop requires roughly 100 days to mature; so that reaping would take place from about the beginning of February to the beginning of March according to the date of sowing.

NOTES.

THE COPPER BLIGHT OF TEA.—This disease was found recently on dried leaves from the Dooars and is probably identical with a blight previously observed in Assam. The first symptom is the appearance of a small copper-coloured spot on the upper surface of the leaf, this spot is irregular in shape and the margin is not very clearly defined, the copper colour gradually passing into the green of the leaf. The surface of the discoloured patch is covered with very minute black spots, which on microscopic examination prove to be areas in which the peripheral leaf tissue has disintegrated, leaving a small crater-like depression. In later stages the discoloration extends right through the leaf appearing as a yellowish brown patch on the under surface, at the same time the copper-coloured area on the upper surface takes on a grayish colour while the margin of the patch becomes sharply defined. The diseased portion of the leaf is now very brittle and is often traversed by numerous cracks.

Detailed examination showed that the black spots in the younger stages were due to the presence of the pycnidia, or spore-cases, of a fungus, situated just below the epidermis of the leaf. They are rounded structures with a very minute aperture at the apex, and consist of a black outer wall of fungal tissue enclosing a central cavity filled with spores. When mature the upper portion of the wall of the pycnidium together with the leaf tissue immediately covering it is thrown off, leaving the lower portion as a crater-shaped cavity full of spores. The pycnospores are oval hyaline structures, each surrounded by a mucilaginous outer coat and with a mucilaginous tail developed at one end. In the older grayish stages of the disease another type of spore-producing organ was found associated with the pycnidia described above. This second fructification or perithecium is the fruiting stage of the Ascomycetous fungus *Laestadia Theae* Racib, which has previously been described as causing a leaf disease of tea in Java. Both a pycnidial and a perithecial fructification essentially similar to the above have also been described as belonging to another species of Laestadia (*L. Vaccinii* Shear), which causes the scald of Cranberries. The connection between the pycnidial and perithecial stages is not in this case absolutely established, but there is at least a strong probability that they are simply different stages of one and the same fungus.

Thus in the only other case known in which pycnidia with the characters described above occurred, they were associated with perithecia of Laestadia. The presumption is as strong as it can be in the absence of adequate cultural experiments that the disease which we have called "Copper blight" is due to the presence of the fungus *Laestadia Theae* Racib at first in the pycnidial and later in the ascigerous stage.

The blight is described as spreading with extreme rapidity; at present it attacks merely the older leaves, probably the rapid spread takes place in the pycnidial stage when large numbers of spores are produced. Plucking off and burning the diseased leaves would decrease the spore production and lessen the chance of infection, but this may not be practicable. Spraying with Bordeaux mixture has been used with success in the case of Cranberry scald and particularly in the case of Black Rot of Grapes, a disease due to another species of Laestadia; it might be beneficial here. In the case of the Java outbreak the disease does not appear to have caused sufficient damage to necessitate preventive measures. In Assam there seems to be some connection between the climatic conditions and the occurrence of the disease, warm sunshine after heavy rain, such as occurs in April, being followed by the appearance of the blight. In this connection it is interesting to notice that the allied disease Black Rot of Grapes is known to be closely dependent on weather conditions.—(F. J. F. SHAW).

AN AGRICULTURAL SCHOOL IN SIND.—A step in advance has been made in Sind by the proposal to establish an agricultural school for young men between 16 and 21 years of age of the cultivating class. The purpose of the school may be best learnt by the following extract from a letter of the Director of Agriculture, Bombay, published in a Resolution of the Government of Bombay :—

"I have the honour to forward copies of No. 4345 of 8th November 1909, from the Commissioner in Sind to this office, with accompaniments, No. C-112 of 10th January 1910, from this office to the Commissioner in Sind, and No. 760 of 7th March 1910, from the Commissioner in Sind to this office.

"2. From this correspondence it will be seen that there is a proposal to start an Agricultural School in Sind for young men of the cultivating classes, the circumstances which led to the proposal being made will be appreciated and the character of the proposed school understood.

"3. In this connection I may mention what is being done in the Presidency proper in the way of agricultural education.

"We now have—

(a) A three years' degree course at the College.

(b) A one year's practical course in English given at the Agricultural College to young men who wish for such instruction to fit themselves for cultivating their own lands.

(c) A two years' vernacular course at the school just commencing work in Poona for the sons of *patels* and substantial landholders, limited to boys of about 14—15 years of age who have passed their 4th vernacular standard. At this school in addition to the agricultural instruction some instruction in reading, writing and arithmetic will be given.

(d) Short courses on the farm. These are given in particular subjects (*e.g.*, seed selection) at the season which suits. It is now proposed to systematise these short courses and advertise them.

"4. The proposed school for Sind will be something between (b) and (c) mentioned above. The course will be given in the vernacular, will last 18 months and will be essentially agricultural ; it will be mainly practical, but will include sufficient theory to enable the boys to understand the practice taught. The age of the students selected will probably be about 16 to 21 ; and the students will be selected from the land-holding and cultivating classes. It is expected that the students will be fitted—

(1) to improve the cultivation of their own lands ;
(2) to manage estates for zemindars ;
(3) to serve in the Agricultural Department.

"5. If the school is started on a modest scale for (say) eight students, the probable expenditure would probably be as follows:—

Initial.

		Rs.
1.	Buildings	[illegible]
2.	Live and dead stock	[illegible]
	Total	[illegible]

Recurring.

1.	Pay of master	[illegible]
2.	Subsistence for eight boys at Rs. 10 per mensem	[illegible]
3.	Miscellaneous	320
		[illegible]

"6. As the school expanded fresh quarters would be required, the pay of the master would increase, and the addition of a second master would be necessary; but it is possible that some of the Local Boards might be willing to finance students of their own selection, which would save further expenditure in that direction. It is also possible that some students might be found who did not require maintenance allowance.

"7. There are no surplus funds at my disposal which will enable me to start such a school this year; but if Government approve of the idea a syllabus of instruction will be prepared, an agricultural graduate put into training for the post of master, and provision will be made for the school in the budget proposals of this Department next submitted. The school could in that case be started in April next, or at an earlier date if the money can be provided by Government in the meantime."

"*Resolution.*—The proposal to start an Agricultural school in Sind is approved. The Director of Agriculture should be requested to make the requisite provision in the budget estimates for 1911-12. The provision should be subject to reconsideration when the budget is settled, and should be treated as optional."

It is to the credit of the Bombay Agricultural Department that it has the courage thus to face circumstances and forge the links that are missing in the chain which has to connect the Provincial Agricultural Colleges with the cultivating classes. We want more of these schools all over India to make feeders for our colleges.—(EDITOR.)

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THE CASTILLOA SCALE-BUG AND ITS DANGER TO TEA.—In the August issue of the *Tropical Agriculturist*, Mr. Ernest

Green, Entomologist to the Ceylon Government, has an interesting and informing note on his discovery of a new scale-bug (*Inglisia sp.*), infesting the Castilloa rubber tree. The matter is of importance not only to growers of the *Castilloa elastica*, but to tea planters who have Castilloa in or near their plantations or are contemplating laying down this variety of rubber, for the pest appears to as easily infest tea bushes as the rubber plant. On a visit very recently paid by Mr. Green to a five-acre clearing of 7½ year old Castilloa trees, he found they were completely overrun by the bug and that not a single tree has escaped infection.

Mr. Green states that the original source of infection remains undiscovered and that it is improbable that it could have been imported with living Castilloa plants. It is a new and hitherto undescribed species of scale-bug and—as far as is known—this is the only locality in which it has appeared.

It would seem that it is a much more serious matter for the tea plant than for Castilloa, for the latter has not been found very profitable in Ceylon, and it would appear advisable to sacrifice it for the sake of the tea. If the pest is allowed to establish itself, Mr. Green opines, it will prove a very dangerous enemy to the tea plant.—(EDITOR.)

⁂

THE AUTOMATIC WATER-FINDER.—This is a simple apparatus supplied by Messrs. Mansfield and Co., of Liverpool, by which any unskilled person may readily ascertain whether a subterranean spring of water exists under a spot where it is desired to sink a well. It indicates the presence of subterranean flowing springs at depths up to 1,000 feet.

To quote from the makers' prospectus, "the principle on which the instrument works is the measuring of the strength of the electrical currents which are constantly flowing between earth and atmosphere, and which are always strongest in the vicinity of subterranean water-courses, the flowing waters of which are charged with electricity to a certain degree. Should a subterranean spring be present under where the instrument has been fixed, the needle commences to move.

* * * * *

If the needle remains stationary, it may be taken for granted that a subterranean spring does not exist under the spot where the instrument is fixed."

The instrument has been tried by the Bombay Department of Agriculture in the trap areas of the Deccan, where underground streams traverse the country in various directions. Mr. H. K. Mehta, M.A., B.SC., of the Poona Agricultural College, was specially put on to this work, and in Bulletin No. 38 of 1910 of the Department of Agriculture, Bombay Presidency, will be found a detailed account of his investigations, during the first five months of 1910. Dr. H. Mann in a preface states that "the results so far obtained, though not absolutely conclusive, indicate an almost certain success. Where wells have failed no indication has ever been found: where successful wells exist, indications are always found; where continuous underground streams are, for other reasons, supposed to exist, the instrument confirms their presence; and where a stream passes near a well so that percolation may be presumed to take place, that percolation is actually found." Dr. Mann is careful to warn us that complete proof must still be awaited, but still Mr. Mehta's experiments would seem to justify the statement that we have come to within measurable distance of a water-finder, whose construction and action are based on scientific principles. There are, however, certain difficulties in the way, such as expense and delicacy in the instrument for details of which the reader is referred to the Bulletin.—(EDITOR.)

⁂

HOW SUGARCANDY IS MADE IN SIND.—In a large iron pan (*Kadhai*), is placed about 20 lbs. of sugar and to it is added 10 lbs. of water. The pan is placed on the fire and all the suspended impurities are removed. Just before boiling half a pound of milk is added to help the separation of dirt and other impurities, which are removed as soon as they come to the surface.

When the syrup becomes clear, the fire is increased gradually and it is boiled till it gets to a particular consistency which can be easily recognised when once seen. Then an earthen vessel, big enough to contain this syrup and which has been kept in water for three days, is taken and on its mouth reed or bamboo splints are spread horizontally and parallel to one another. From these, threads are hung, the other ends of which are secured to the bottom of the vessel by paste made from wheat or rice flour. The syrup is poured into this vessel and kept till the crystals form. It takes about 3 to 6 days according as the temperature of the locality is high or low. After this period, the uncrystallisable liquid is removed and the vessel is kept in the sun for a short time. When dry, the pot is broken and a lage lump of crystallised sugar is taken out. The strings serve as aids round which the crystals first aggregate.—(G. S. KULKARNI.)

⁂

POTATO DISEASE ON THE NILGIRIS.—Owing to a serious outbreak of potato disease in the Nilgiris, Mr. W. McRae, M.A., B.SC., Mycologist to the Government of Madras, was deputed to make an investigation of the same and advise as to its treatment. The following extract from his recent report will be of interest :—

"For a considerable number of years disease has been prevalent in the potato crop in the Nilgiris. The cultivators know the diseases quite well but, being ignorant of the cause and the method of spread, exercise only the crudest methods of avoiding them. Hitherto only two potato diseases have been reported from this district—

(1) Irish Blight.

(2) Bangle Blight, otherwise ring disease or *bangadi*.

In the month of May in Ootacamund, there was no sign of the former disease though much of the latter. This is not anomalous, as Irish Blight is a late blight and the crop was in the early part of its season. Another Blight was also common. It is identical with the American (3) Early Blight and has hitherto been reported in India only from the United Provinces. Like Irish Blight, it attacks the leaves and the two have been confused since more than one European showed it to me as Irish blight. It is more common at this time of year than Bangle Blight.

Occurrence of the three Blights.—Irish Blight occurs in nearly every country where potatoes are growing. It is said to have been in the Nilgiris for many years. *Early Blight* is well known in North America where it does considerable damage, and in Western and Central Europe where it does a fair amount. It occurs also in Australia, New Zealand and South Africa. It was reported from the United Provinces in 1907. This is the first time it has been reported from the Nilgiris. *Ring Blight* has been a long time in the district. It was reported from the Nilgiris in 1903 by Capell. It occurs also in India in Bombay, Bengal and Mysore. It is known in Europe, America, Australia and New Zealand.

Symptoms.—A short note on the symptoms will now be given—(1) Irish Blight may be omitted as it was not seen in May.

(2) Early Blight is confined to the leaves and stems. It begins to show about the time the young tubers are beginning to form. On the leaves, small light-brown spots with well-defined edges appear and gradually increase in size and deepen in colour. Faint concentric lines mark the successive edges of the spot, and this is a mark easily distinguishing Early Blight from Irish Blight in which the spots are not so marked and the edges of the spot are not so clearly defined. These spots, too, become rather brittle and dry, instead of soft and foul-smelling as in the Irish Blight. The spots gradually spread over the leaf surface till the leaves succumb. The stems too may be spotted. Ultimately the whole shoot perishes. No signs of the disease getting into the tubers were noticed. What seems to befall them is that they remain small and fail to reach maturity, because the aerial shoot is weakened and killed before it has produced enough good material for the development of the tubers.

(3) *Ring Blight.*—The symptoms are the same as those described by Coleman in Bulletin No. 1 of the Mysore Agricultural Department. Individual plants and little groups of plants show signs of flagging and wilt suddenly. On digging up and slicing the tubers of the affected plants, small, dark, discoloured spots may be seen forming a ring just within the periphery in the region of the vascular bundle ring. A section across the collar of the stem shows a similar discolouration. Under the microscope, the water-conducting tubes and adjacent cells are seen to be filled with masses of bacteria. These choke up the water-conducting tubes and cut off the supply of water to the green leaves which immediately droop and hang down, just as cut flowers do, if not placed in a vessel of water.

Spraying.—Any treatment that may be suggested can only be preventive not curative. When once a plant has been attacked nothing can save it. In other countries potatoes have proved to be one of the crops most amenable to treatment for disease. In all western potato-growing countries, spraying has become a routine operation in those districts where disease is severe. For two of the diseases reported to occur in the Nilgiris (Irish Blight and Early Blight), spraying has been found most efficacious, though for the third (Ring Blight) it is of no use. Bordeaux mixture (1:4:50) applied, when plants are four to six inches high, *i.e.*, just before Early Blight is expected to appear, and repeated at intervals of a fortnight till five or six treatments have been given, is the fungicide most useful. This treatment would be applicable for the second or autumn crop, but for the first or monsoon crop, I am doubtful. In the latter case, the first application would be given early in May and the others successively till the end of July. The character of the monsoon rains would probably render spraying useless by washing off the spray from the leaves. It is not expected that spraying will be introduced among cultivators now. Some of the European cultivators whose crops are badly diseased would find it worth their while to spray. Later on the smaller growers might take to spraying when they saw it paid. A simpler type of sprayer than those of the market at present might be evolved suitable for the work.

Field Sanitation.—Collecting and burning all stalks and leaves and carefully removing all small or rotten potatoes from a diseased field, so as to avoid their rotting on the ground and carrying on infection from one crop to another is a *sine quâ non* before the slightest improvement can be expected. Now the cultivators leave the vines and the bad tubers on the ground to decay, because they do not understand how the disease is carried. Unless this is thoroughly attended to, it is useless to do anything to combat disease.

Seed.—Diseased tubers should not be utilised for seed. It is not always possible to tell by the naked eye whether a tuber is diseased or not, hence seed should never be taken from the produce of a diseased field.

Rotation.—The expense of enclosing the ground is so considerable and the crop is so profitable that it is grown in both seasons year after year in the same land and the unwillingness of the cultivator to rotate it with less valuable produce, even when disease is severe, is one of the chief difficulties to be met. Such a practice is bound to break down the constitution of the potato and to produce a weak crop susceptible to disease. If Bangle Blight has been severe on a field, the ground should have a rest from bearing potatoes for at least one year, and perhaps more may be necessary, as the bacteria live in the soil certainly for one year. Oats and barley are grown to some extent in the hills and though not bringing the return of a potato crop are still valuable enough to form a rotation crop with it.

New Seed.—The importation of new varieties should be encouraged. At the present time, however, potatoes from Europe ought to be treated with suspicion because of the wart disease (*Chrysophylictis endobiotica*) which, during the last few years, has spread rapidly over England and the Continent of Europe and has reached Newfoundland. The Australian Colonies and New Zealand are suitable places from which to get new seed and a guarantee may be had with the seed stating that it is free from disease. Mr. G. Oakes last year introduced three such varieties from New South Wales. They were guaranteed disease-free and on testing in new soil proved to be so. Now they want to be tested for disease-resistant quality.

Disease-resistant Varieties.—A disease-proof variety is an Utopian idea. A more or less disease-resistant variety may be evolved by continuous selection of varieties grown in a diseased locality. If introduced varieties and the best of the varieties now in the district were grown in badly diseased land, they would be found to differ greatly in their susceptibility. The produce of the few disease-free plants would be carefully selected each season and used as seed for the succeeding season. This process would be repeated for several seasons. From one or more of these varieties it would be possible by selection in this way to evolve a potato that was resistant to disease. Coleman has been doing this for some time in Bangalore against Bangle Blight and his experience will help us. It has been found that a variety resistant to a disease in one locality may not show that resistance in another locality and it is probable that disease-resistant varieties will have to be evolved in the Nilgiris for the Nilgiris. Loss of resistance in a potato occurs after a few years' cultivation; hence, constant attention is required to keep up a good standard of cultivation and the seed should be continuously selected. There is no official means of doing this in the Nilgiri district. The Collector is keen and Mr G. Oakes and a few others are interested, and as far as I can see, it must be left to private enterprise.

There is no doubt that the problem of reducing disease among potatoes in the Nilgiris and keeping it under control is a difficult one. Under the present system of cultivation, everything is done to favour the introduction of disease and to foster it, once it has come. But by paying attention to field sanitation and the choice of seed, by the introduction of a rotation and by the propagation of resistant varieties, the losses due to disease may be largely overcome.

To sum up—

(1) These are the common diseases to be guarded against :—

Irish Blight
Early Blight.
Bangle Blight.

(2) Contaminated seed is being used. Diseased tubers should not be used as seed, and seed should not be taken from the produce of a diseased field.

(3) Two potato crops are grown year after year on the same field. Rotate with oats or barley or any other crop, but not with brinjals nor tomatoes.

(4) The vines as well as small and diseased tubers are left in the ground to carry on disease from season to season. Crops should be carefully lifted and no tubers left in the ground. The vines and rotten diseased potatoes should be carefully collected and burned.

(5) The bacterium causing one of the diseases (Bangle Blight) lives in the soil for more than one year. When this disease is prevalent in a field, rest the soil for at least one year by leaving it fallow or by rotating.

(6) Disease is accumulating year after year. New varieties should be introduced and tested. These, as well as good varieties already in the district,

should be selected and those that prove to be resistant, put on the market. This should go on continuously so as always to have a new variety coming on, when the disease-resistant powers of those on the market break down."

⁂

FIBRE CONGRESS AND EXHIBITION IN JAVA.—In July 1911 under the auspices of the Netherlands Indian Agricultural Association, and assisted and patronised by the Dutch Government, a Fibre Congress and Exhibition will be held at Sourabaya in Java. The aims of the Congress and Exhibition are :—to further the cultivation of fibre plants in the tropics, to advise planters regarding their culture, to discuss points on which there is now difference of opinion, to attain uniformity in methods of production and in products, and to arrive at a proper insight as to the value of cultivating fibre plants both on a large and a small scale. The consideration of cotton, it is reported, will be excluded.

The Congress and the Exhibition will be opened on the 3rd July 1911, by the President of the Netherlands Indian Agricultural Association and will be closed on the 8th idem. The second day will be devoted to discussing the cultivation and preparation of the Agave fibres, especially sisal hemp, and the third, to Manila hemp and jute and the substitutes for the latter. On the 4th day the cultivation and preparation of Kapok and pine-apple fibres will be discussed. On the 5th day the trials of fibre extracting machines will be held, to give the visitors and planters an opportunity of judging their merits. The sixth and the last day will be devoted to the discussion of points relative to the productiveness of the cultivation of fibre plants, the presentation of diplomas, etc.

The Congress and the Exhibition ought to prove of great value to those who are now interested in the extension and cultivation of fibre plants in India.—(EDITOR.)

⁂

WILD INDIGO (TEPHROSIA PURPUREA; TAMIL, *Kolinchi*; TELUGU, *Vempali*) AS GREEN MANURE FOR PADDY LANDS.—Wild indigo is an erect shrub growing up to 3 feet in height and 3 feet in diameter at top. The plant belongs to the family of pulses and is recognised as one of the best green manure crops there is in the country. It has a long tap root which strikes on plant food from the deeper layers of the soil and is a means of improving the texture and the moisture retaining quality of the land. It possesses the power or means of absorbing nitrogen from the air.

The plant is generally found on high level waste lands, plains and fallow lands which are fairly loose in texture. It is keenly sought after for manure during the cultivation season when it is spread and trodden in the land which has been puddled for the sowing or transplanting of paddy. It is carried in carts or as head-loads at a great cost to distances varying from 1 to 50 miles; a half ton load, costing Rs. 3-8 at Sivagiri, costs Rs. 10 at Ambasamudrum which is 45 miles away. Under these circumstances there arose a question as to why, when the plant grew on certain lands, it should not be grown on similar lands on which it could be directly used as manure without the expense and trouble of collecting the leaf from long distances outside. Accordingly, experimental sowing of the seed on a large scale was first started at Sivagiri in the Tinnevelly district with very successful results, and it has now become a common practice to collect the seed for sowing and sale in the locality, as it has been thoroughly proved that with a couple of ploughings and a few measures of seed one to two tons of green manure can be easily produced on the spot.

The Agricultural Department is taking much interest in spreading the practice also in other districts by purchasing the required quantity of seed at Sivagiri. During the present season the Department purchased 200 bags or more than 14 tons of seed for the district of Tanjore alone.

The seed should be first sown on the land at the rate of three Madras measures or 10 lbs. per acre and then covered with one or two ploughings as is generally done in the case of pulse crops.

It may also be sown along with gingelly as a mixture when it thrives and forms a good green manure after the harvest of gingelly. When sown under favourable conditions a good portion of the seed germinates within about a week, the remaining portion sprouting in batches at different times later on. The chief peculiarity of this seed is that it lies dormant in the soil for even a year without losing its vitality. There are several instances in which the seed did not germinate the first season it was sown, but yielded a satisfactory green manure crop after the succeeding crop of paddy had been harvested, the seed lying dormant in the soil throughout the period the paddy crop was occupying the land.

Occasional showers help the crop to come up well, but continuous heavy rains producing water-logged conditions even for a day would kill it, especially a young crop. The crop should therefore be sown at the end of the rainy season. After five or six months' growth it can be ploughed in and applied as green manure for the succeeding grain crop.

Single-crop-wet lands under tanks and canals will be immensely benefited by growing this crop instead of allowing them to lie waste and weedy for about 6 months in the year.

It is a known fact that the generality of ryots are now unable to provide sufficient manure for all the land they hold and this, sooner or later, must have a serious effect on the yield of their crops. The best advice, therefore, is to grow a green manure crop during the period the land lies empty in order to increase or at least maintain the fertility of the soil.

As goats and cattle do not relish wild indigo there is no fear of the crop being destroyed by stray animals.

This crop will not grow on the stiff and saline soils, but even these are known to bear a crop of wild indigo when improved by continuous and heavy applications of tank silt, sand, and leaf manure, obtained from outside.

If the organic matter in the soil could be sufficiently increased by persistent growing of green manure crops, the land in course of time becomes sufficiently loose and retentive of moisture to allow the wild indigo crop to come up well from the self-sown seed without even the necessity of ploughing after the harvest of paddy.

Wild indigo can also be sown on dry land as a mixture with gingelly or with the final hoeing of other crops. In this case also it can be applied as manure by being ploughed in either standing or after being cut and spread on the land —(A. RAMA RAO.)

REVIEWS.

Dry-Farming: Its Principles and Practice. By William Macdonald, M.S. Agr., Sc.D., Ph.D., Foreign Vice-President and Corresponding Secretary for the Dry-Farming Congress. (T. Werner Laurie, London.)

As stated in the preface, the aim of this volume is to set forth in a plain way the salient facts of that new branch of agricultural science which is now known as dry-farming. It will well repay perusal by any one interested in the agriculture of arid or semi-arid regions in which India is included. Dry-farming is defined as "the conservation of soil moisture during long periods of dry weather by means of tillage, together with the growth of drought-resistant plants." It is not of course farming without moisture, for that would be clearly impossible. The phrase is now loosely applied to a particular form of farming in all places where the rainfall ranges from zero to 30 inches per annum. It is, however, much more a question of the distribution of a limited amount of rainfall than any total amount per annum. Thus, while 30 inches of rain well distributed throughout the year in some countries would require no particular efforts on the part of the farmer for conserving the moisture, if this same 30 inches all fell in three months of the year leaving practically a rainless period of nine months, considerable ingenuity would be necessary to conserve the moisture and grow crops during that latter period.

In India, the subject of dry-farming is of considerable interest, but it should be noted that the practice is already not unknown. Indeed, the *Rabi* crops of the cold weather months have to be grown on the moisture supplied by the often scanty three months' rainfall of the monsoon. The Indigo Planters of Behar, before the introduction of Java indigo plant which is sown in September, depended entirely on the moisture of the three months rain in the monsoon on which to sow and germinate their indigo crop in the following March. The methods they adopted during that period of practical drought from October to March were with a view of conserving the moisture of the soil. They not only included deep digging and ploughing, but also the closing and pressing down of the soil so that the moisture from below might rise to the surface, the keeping clean of weeds and the breaking of the surface and formation of a mulch whenever a crust was formed by unexpected rain. So too the native cultivator in regions where the rainfall is barely sufficient, or the physical nature of the soil renders it unretentive of moisture, uses methods of tillage and sowing which may rightly be classed as belonging to the process of dry-farming. While, therefore, it has perhaps been reserved to America to work out the principles underlying dry-farming, I venture to think, the practice, so far as India is concerned, is of some antiquity. Yet it is only by knowing and understanding scientific principles and the experience of others that progress and improvements can be achieved so that the Indian Agriculturists may well learn from their brethren in America. In that country in tracts where the rainfall is markedly deficient, not only is tillage and the growth of drought resistant plants resorted to but the holdings are of such a size that the farmer is enabled to place one portion under treatment without crops for a whole year with the sole object of preserving the moisture, another portion under crops and a third in pasture for his stock. The proportions are usually one quarter in fallow, one quarter in crops and one half in pasture. It is, therefore, possible that one of the methods which might, with advantage, be tried in India, where lands are at present uncultivated and considered unprofitable for want of sufficient moisture, is to give out to cultivators holdings four times the usual size. The characteristics in dry-farming on which stress is laid in America are (*a*) a deep initial preparation of the land, (*b*) constant shallow after-cultivation, (*c*) fallowing the land every other year, where rainfall is generally deficient, (*d*) the growth of drought-resistant crops, (*e*) restricting the number of crops to a few staple crops such as wheat, barley, etc., and (*f*) placing half of the whole holding under pasture for stock. An important matter, however, must be noted that all soils do not lend themselves to dry-farming and therefore, the most important factor in the whole of this subject and one which must be ascertained before anything else is done, is the nature and quality of the soil. The soil should be looked upon as a reservoir for the storage of water over periods ranging from a few weeks to many months. Those which retain rainfall best are sandy loams having a supply of well decomposed vegetable matter. Clay soils are unsuitable, as the moisture does not rise fast enough to supply the plant during spells of very dry weather. Soils known to be poor in lime should be avoided or supplied with the required lime. Naturally, poor soils can be greatly improved and made good dry-farming soils by green manuring or the application of farm-yard manure, but the application of commercial fertilisers is seldom of much practical benefit to the dry-land farmer who needs more a moisture-retaining soil rather than a temporary artificial stimulant to plant growth.

Mr. Macdonald has rendered a great service by placing within reach of any interested in the cultivation of arid land such a complete and clear statement of the principles and practice of dry-farming, and it is to be hoped that members of the Agricultural Department interested in the subject will make use of the useful information he supplies.—(Editor.)

* *

Fourth Annual Report of the Committee of Control of the South African Central Locust Bureau. (Cape Town.)

The Central Locust Bureau of South Africa was formed in 1906 to collate reports from the various Colonies of South Africa regarding locusts, mainly their occurrence and movements, in order that, over the whole area, measures against them could be correlated and the best methods of procedure should be widely known. The British Colonies contribute to the cost as do also German South-West Africa and Portuguese East Africa. Every month the Bureau issues maps showing the occurrence of locusts over the whole area, and these are, at the end of the year, united to form this report. It is probable that the work of the Board will devolve upon the Department of Agriculture of the Union Government.

There are, in South Africa, two locusts, neither occurring in India. Their occurrence varies from year to year, and the year 1909-10 was marked mainly by their comparative absence. One species occurred scarcely at all in British territory and hoppers were found only in Mozambique and in Natal, the cost of fighting them in the last being under £50. The second locust occurred lightly in German South-West Africa, seriously in the Orange River Colony and the Cape Colony, enormous swarms having come in from the Kalahari Desert. A strip of country 200 miles wide was infested and enormous swarms of hoppers hatched. These were destroyed vigorously and the country was practically cleared of locusts. They anticipate a few years' freedom from the pest. Practically the sole remedy used is the application of a strong solution of arsenic with sugar to the vegetation the hoppers are about to eat. This solution is issued ready made and about 12,600 gallons were used. There were a few cases of stock poisoning due to gross carelessness in the use of the mixture. In the Orange River, the mixture is not sprayed direct on to the growing vegetation but succulent green fodder is cut, poisoned and laid out for the hoppers.

It is an extremely instructive thing to realise how little danger there is in the use of arsenical poisons in this way; the method used has been tried in India and abandoned on account of its supposed danger. Yet here is another year's experience under very similar conditions in South Africa and they report successful use of the method. In India, the use even of very dilute non-soluble arsenical poisons such as Lead Arseniate is, by the ordinary man, looked on with horror and the use of insecticides generally is almost unknown. Our locusts are very different to those of South Africa and the poisoned bait-method could scarcely be used, but it is as well to realise that over large areas of land they use freely a solution containing twelve times as much arsenic as in an ordinary spray for crops.

The Locust Bureau and the territory they work over are to be congratulated on the success they have attained and the very solid work done. The report affords interesting reading, is well illustrated, and the maps are most valuable.—(H. M. LEFROY.)

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